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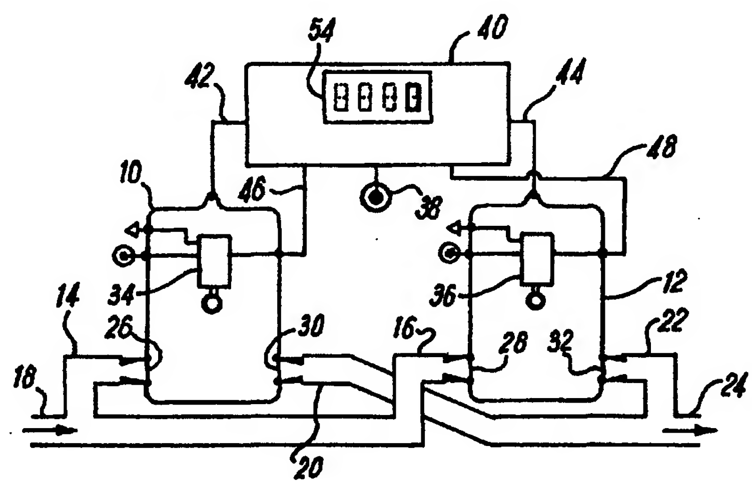

(57) Abstract

Liquid recovery apparatus comprises first and second liquid holding vessels (110, 112), a vacuum pump (156) adapted to apply a vacuum selectively to one or other of the vessels and control means (140) adapted to switch the vacuum from one vessel to the other when the liquid level in the one vessel reaches a maximum level, the liquid contained in the one vessel being discharged therefrom while liquid continues to be collected in the other vessel. The apparatus operates in a cyclic manner to continuously recover liquid into the vessels alternately. The liquid level is monitored by uppermost float valves (134, 136). Liquid discharge is facilitated by pressurising the vessel after the liquid reaches the uppermost level, the pressure being removed when the liquid falls to a lowermost level detected by lowermost level detectors (176, 178). The apparatus is pneumatically powered and controlled, and utilises a venturi type vacuum pump.

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"Liquid Recovery Apparatus"

This invention relates to liquid recovery apparatus. The invention relates particularly but not exclusively to such apparatus for use in the recovery of spilled fluids, sludges and effluents, which may or may not contain solids, and for subsequently transferring them to another more convenient location such as a collector tank.

In its preferred form, the apparatus is powered and pneumatically controlled by compressed air, the suction being provided by a pneumatic ejector(s), working on venturi constant level suction principle with no moving parts, for subjecting a first collection vessel to sub atmospheric pressure (vacuum) whereby liquid is sucked into the first vessel. When the first vessel is full, discharge of the liquid therefrom is facilitated by subjecting the same vessel to positive pressure. While recovered liquid is being discharged from the first vessel, the vacuum is instantaneously switched to a second vessel and liquid recovery continues. Since suction is never lost, the invention gives continuous suction but with automatic intermittent discharge meaning that the operator does not have to wait to

continue operations while a holding tank is discharged.

This "multi-vessel" system will consist of at least two pressure vessels but may have more than two vessels depending on the nature and amount of material to be recovered.

The apparatus is used in a similar fashion to a domestic household vacuum cleaner. The user will "sweep up" the spillage using a suitably designed suction head which will be connected to the invention by means of a flexible suction hose. A similar such hose will be employed to carry the discharge medium to the desired location.

The apparatus is intrinsically safe due to the fact that it is air powered, thus eliminating the requirement for detailed safety certification in the field of use.

In its preferred form, the invention is pneumatically controlled and powered, so that it does not present an explosion risk. Accordingly, it is envisaged that it may be used in explosive and hazardous environments examples of which being underground mines, offshore or onshore drilling installations for oil, gas or the like, or empty fuel silos. It might also be employed advantageously in non-hazardous environments, in which case it may be controlled and powered by other means, including electrical and/or hydraulic means

A number of types of liquid recovery apparatus are known for use in the types of liquid recovery application for which the present invention is particularly intended, as follow:-

1. Double diaphragm reciprocating pumps. A number of makes and variations of this type of equipment exist.

2. Venturi operated (constant suction level) pumps, which have been in existence for over forty years. Pumps of this type are generally known as CP72 type pumps.

3. EP-B-0 162 074 discloses liquid recovery apparatus in which liquid is collected in a single vessel, and is automatically discharged when the vessel is full, whereafter liquid recovery continues. This apparatus is essentially a combination, in working principle, of a CP72 pump (for suction) and a double diaphragm reciprocating pump (for discharge) with a holding vessel set in between.

These existing types of apparatus have the following advantages (a) and disadvantages (d):-

1a) The double diaphragm reciprocating pumps provide continuous suction and discharge and have a fairly simple internal (albeit antiquated) control system.

1d) The construction of these pumps is a limiting feature insofar that if a piece of debris is picked up (eg stray bolt), it can cause severe internal damage frequently resulting in having to replace the pump casing. A filter is therefore required on the suction line to overcome this problem which limits the actual suction ability. Operators are known to dispose of these filters in the attempt to increase suction.

The mechanical method in which the suction is

created (reciprocating diaphragms) also causes a minor "sinusoidal" suction and discharge effect. The created suction is therefore not at a constant level and, in order to work effectively, the suction head ideally is required to be submerged in the fluid medium which is being recovered.

2a) CP72 sludge pumps have venturi (constant level) suction and very few moving parts.

2d) The CP72 sludge pump has a very antiquated ball-float pneumatic control system which is easily damaged by any recovered fluids other than non-contaminated water. Repair down-time is therefore quite high.

The single pressure vessel principle of the CP72 pump also means that there is alternate suction and discharge. That is to say that the vessel is subject to vacuum and when full of recovered fluid the vacuum ceases and the vessel is subjected to a positive pressure which forces the recovered fluid to another location by means of a discharge hose. This happens fairly quickly and can cause a hazardous "whipping" effect on the discharge hose. The rapid successive suction and discharge also causes frequent breakdown on the control system.

3a) Apparatus of the type disclosed in EP-B-0 162 074 has venturi (constant level) suction and modern pneumatic control system.

3d) Such apparatus employs double diaphragm reciprocating pumps for discharge purposes and, similar to (1d), will be easily damaged if any debris enters the holding vessel. A filter is

therefore employed on the suction line to overcome this problem, but it is known that these are frequently removed by operators and disposed of to help improve suction ability. The repair/servicing down-time for this equipment is therefore quite high.

Similar to (2d), the single holding vessel principle of this apparatus means that there is alternate suction and discharge. That is to say that the vessels subject to vacuum and when full of recovered fluid the vacuum ceases and the discharge pump removes the recovered fluid from the vessel, transferring it to another location by means of a discharge hose.

The discharge cycle for this apparatus has a preset time which is normally suited to fluids which have similar properties to water. This means that fluids which are lighter or less viscous than water will be discharged very quickly resulting in air being pumped into the discharge hose which may create a hazardous whiplash effect when fluid re-enters the discharge hose on the next discharge cycle. Equally, fluids which are heavier or more viscous than water (or where the discharge fluid has to be raised above a significant height) will not be given sufficient time to entirely empty the holding vessel.

It is an object of the present invention to provide liquid recovery apparatus which obviates or mitigates one or more of the foregoing disadvantages of existing types of apparatus.

In accordance with a first aspect of the present

invention there is provided apparatus for recovering liquids, comprising first and second vessels for liquid, vacuum pump means for applying a vacuum selectively to the first and second vessels, each vessel having an inlet for recovered liquid which includes valve means restricting liquid exit from the vessel, and an outlet through which liquid is discharged from the vessel, the outlet including valve means which restricts liquid entry to the vessel, and a conduit connected to said inlets to convey recovered liquid to the vessels.

Preferably, the apparatus further includes control means including switching means adapted to switch the applied vacuum from one vessel to the other in response to a control signal indicating that the liquid level in said one container has reached a predetermined maximum level and to cause the liquid collected in said one container to be discharged via said outlet of said one vessel.

More preferably, said control means is adapted to apply said vacuum is alternately to said first and second vessels in a cyclical manner such that recovered liquid is drawn into one of the vessels via its inlet whilst any previously recovered liquid is discharged from the other vessel via its outlet, the vacuum being switched from said one vessel to said other vessel when the recovered liquid in said one vessel rises to said predetermined level, such that recovered liquid is drawn into said other vessel whilst the previously recovered liquid is discharged from said one vessel.

Most preferably, said control means comprises pneumatic control means.

Preferably also, said control signal is generated by first liquid level sensors located in each of said vessels. Said sensors preferably comprise float valves.

Preferably also, said vacuum pump comprises a venturi ejector type pump.

Preferably also, the valve means of said inlets and outlets comprise one way check valves.

Alternatively, the valve means of said inlets and outlets comprise pneumatically actuated valves. Preferably, said pneumatically actuated valves are normally closed valves.

In one embodiment of the invention, the period during which liquid is discharged from said one vessel is determined by timer means.

Preferably, said control means is further adapted to cause a pressure to be applied alternately to the interiors of said first and second vessels when recovered liquid is to be discharged therefrom.

More preferably, said control means is further adapted to cause said pressure to be applied to the interior of said one vessel when the liquid level in said one vessel reaches said first level.

In a preferred embodiment of the invention, said control means is further adapted to cause said inlet valve means of said one vessel to close, said outlet valve means of said one vessel to open, said inlet valve means of said other vessel to open and said outlet valve means of said other vessel to close when the liquid level in said one vessel reaches said first

level.

Preferably also, said first and second vessels each includes second level detector means for detecting when the level of recovered liquid in the vessel falls below a second, lower, predetermined level.

Most preferably, said control means is further adapted to apply a pressure to the interior of said one vessel while liquid is being discharged therefrom and to remove said applied pressure from said one vessel when the liquid level in said one vessel falls below said second level.

Preferably, said outlets of said first and second vessels are connected to a common discharge conduit, said discharge conduit including discharge valve means.

Preferably said control means is further adapted to cause said discharge valve means to close when the liquid level in said one vessel falls below a lowermost predetermined level and to open when the liquid level in said other vessel exceeds an uppermost predetermined level.

Preferably, the apparatus further includes counter means adapted to be incremented at a predetermined point in the cyclical operation of the apparatus. Most preferably, said counter means is incremented when the vacuum is switched from one of said first and second vessels to the other.

Preferably also, the apparatus further includes manually operable control means whereby recovered liquid may be discharged from said first and/or second vessels.

In accordance with a second aspect of the invention there is provided apparatus for recovering liquids, comprising at least a first vessel for liquid, vacuum pump means for applying a vacuum selectively to said at least one vessel, said at least one vessel having an inlet for recovered liquid which includes valve means restricting liquid exit from the vessel, and an outlet through which liquid is discharged from the vessel, the outlet including valve means which restricts liquid entry to the vessel, and a conduit connected to said inlets to convey recovered liquid to the vessel, and further including first liquid level detecting means for detecting when the liquid level in said at least one vessel reaches an uppermost predetermined level and second liquid level detecting means for detecting when the liquid level in said at least one vessel reaches a lowermost predetermined level, and control means responsive to said first and second level detecting means and adapted to remove said vacuum from said at least one vessel and to cause liquid contained therein to be discharged from said vessel when said liquid level reaches said uppermost predetermined level and to cause said vacuum to be reapplied to said vessel when said liquid level falls to said lowermost predetermined level.

Embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Fig. 1 is a schematic representation of liquid recovery apparatus in accordance with a first embodiment of the invention;

Fig. 2 is a schematic, perspective drawing of a suction head attached to a liquid recovery conduit for use with the present invention;

Figs. 3 to 8 are more detailed schematic representations of the apparatus of Fig. 1 illustrating the cyclical operation of the apparatus;

Fig. 9 is a schematic representation of liquid recovery apparatus in accordance with a second embodiment of the invention;

Figs. 10 to 19 are more detailed schematic representations of the apparatus of Fig. 9 illustrating the cyclical operation of the apparatus;

Fig. 20 is a schematic representation of liquid recovery apparatus in accordance with a third embodiment of the invention;

Fig. 21 is a more detailed schematic representation of the apparatus of Fig. 20;

Fig. 22 is a schematic front view illustrating the physical arrangement of an example of a liquid recovery apparatus in accordance with the second or third embodiments of the invention;

Fig. 23 is a schematic side view of the apparatus of Fig. 22; and

Fig. 24 is a schematic top view of the apparatus of Fig. 22.

Referring now to the drawings, Fig. 1 shows the general arrangement of a first embodiment of liquid recovery apparatus in accordance with the invention. The apparatus is powered by compressed air and is pneumatically controlled.

The apparatus comprises first and second vessels 10 and 12 for the collection of recovered liquid. Each of the vessels has an inlet 14, 16 connected to a common inlet conduit 18, and an outlet 20, 22 connected to a common discharge conduit 24. Each of the inlets 14, 16 and

outlets 20, 22 has a one way check valve 26, 28, 30, 32 respectively associated therewith. Each of the vessels 10, 12 also has a float valve 34, 36 located in its interior adjacent the upper end of the vessels for detecting when liquid in the vessels reaches a predetermined uppermost level.

The apparatus is powered by an air supply 38 which is connected to a control box 40. The air supply serves to power a vacuum source (not shown, described in greater detail below) for liquid recovery and to operate the pneumatic control means of the apparatus. The control box 40 is connected to each of the vessels 10, 12 by means of air lines 42, 44 communicating with the interiors of the vessels to apply a vacuum thereto for liquid recovery and to pressurise the vessels to facilitate the discharge of recovered liquid, and by means of pneumatic control lines 46, 48 connected to the float valves 34, 36.

The pneumatic control means of the apparatus operates such that vacuum is applied to one of the vessels 10, 12 until the float valve of the vessel operates to indicate that recovered liquid has reached a predetermined level. At this point the vacuum is switched to the other vessel so that liquid continues to be sucked into the other vessel while the previously recovered liquid is discharged from the first vessel. The apparatus thus cycles between the first and second vessels so that liquid recovery can continue substantially without interruption during operation of the apparatus. The operation of the apparatus will be described in greater detail below.

Fig. 2 illustrates a suction head 50 for connection to the inlet conduit 18, for the recovery of liquid 52.

In general working principle the vacuum pump of the apparatus is not unlike the idea of the CP72 sludge pump described above. However it differs principally by virtue of the fact that it has two liquid holding vessels. This means that in working operation one vessel will be subjected to a vacuum and when this vessel is full of recovered fluid, the vacuum is automatically and instantaneously transferred to the other tank.

When the currently active vessel is full the recovered fluid is transferred to another location by subjecting the vessel to positive pressure for a set period of time determined by a pneumatic timer within the control circuitry, during which period the vacuum is transferred to the other vessel. Therefore the apparatus will always provide continuous suction for the operator. A manual discharge valve is also fitted for the purpose of giving the operator the chance to totally empty the vessels when operations are complete.

The control box 40 includes a resettable pneumatic counter 54 linked to the control circuity. The counter 54 increments by one each time the vessels change over. By knowing the volume of each tank (suitably 20 gallons (imp) approximately), the counter can be used to provide an indication of the volume of the spilled fluid which has been recovered.

As will be described in more detail below in relation to a second embodiment of the invention, the apparatus may be modified to include ball float valves in the bottom of the vessels to detect when the vessels have been emptied. This eliminates the requirement for a pneumatic timer. In addition to this, pneumatically actuated valves may be added to replace the one way

"Check" valves 26, 28, 30, 32 on the vessel suction and discharge ports 14, 16, 18, 20 which in this example are sealed by the combination of gravity and the action of pressure/vacuum. Such modifications would also require appropriate modifications of the control circuitry.

There now follows a more detailed description of the working principle of the first embodiment of the invention, with reference to Figs 3 to 8 of the drawings.

The apparatus gets its vacuum by means of a venturi ejector 56. In a venturi system of this type the exhaust port has a smaller area than the inlet area. Because the air volumetric flow rate is the same at each port of the venturi, the actual air velocity increases resulting in a loss of pressure at the exhaust. Hence a vacuum is created.

The apparatus operates in a cyclical manner as shall now be described.

Stage 1

With reference to Fig. 3, the suction line 58 from the venturi ejector 56 passes through a purge valve 60 and a transfer valve 62 and hence a vacuum is applied to the first vessel 10. The outlet port one way check valve 30 of the first vessel 10 is pulled closed by the vacuum whilst the inlet port check valve 26 is sucked open. As the operator applies the suction head 50 to the spillage 52, fluid is sucked into the first vessel 10 which then begins to fill. At this stage nothing else is happens within the rest of the apparatus.

Stage 2

When the first vessel 10 is full as shown in Fig 4, the ball float 64 attached to the float valve 34 is forced up causing the float valve 34 to change from position 1 to position 2. This sends a pneumatic pilot signal to transfer valve 62 causing it to change to position 2 and to a shuttle valve 66 which also changes to position 2. The signal out of the shuttle valve 66 causes the pneumatic counter 54 to advance by one and causes a discharge control valve 68 to change to position 2. As the transfer valve 62 is now in position 2, the vacuum from the venturi ejector 56 and purge valve 60 has now been transferred to the second vessel 12 which subsequently begins to fill. The outlet port one way check valve 32 in the second vessel 12 is pulled closed by the vacuum whilst the inlet port check valve 28 is sucked open. Meanwhile, because the discharge control valve 68 is in position 2, an air supply is sent to the first vessel 10 via the transfer valve 62 causing the recovered fluid to discharge. The inlet one way check valve 26 in the first vessel 10 will be forced to close whilst the outlet check valve 30 will be forced to open due to the discharging fluid. The air supply from the discharge control valve 68 is also supplied to a pneumatic timer 70 which begins to charge by means of a reservoir 72.

Stage 3

After a pre-determined period, the reservoir 72 of the pneumatic timer 70 is full causing the timer 70 to change to position 2 as can be seen in Fig 5. The timer sends a pilot signal to the discharge control valve 68 which then reverts back to position 1. This has the effect of resetting the timer 70 and stopping

the air supply to the first vessel 10 which now should have all of its contents discharged. Because the timer 70 has reset itself, it now reverts back to position 1. The float valve 34 inside the first vessel 10 will also have reverted back to position 1. This means that the pilot signals which were sent from float valve 34 to transfer valve 62 and discharge control valve 68 will have exhausted to atmosphere. Whilst all of this is happening, the second vessel 12 currently being subjected to vacuum continues to fill.

Stage 4

When the second vessel 12 is full as shown in Fig 6, the ball float 74 attached to the float valve 36 of the second vessel 12 is forced up causing this float valve 36 to change from position 1 to position 2. This sends a pneumatic pilot signal to the transfer valve 62 causing it to change to position 1 and to the shuttle valve 66 which also changes to position 1. The signal out of the shuttle valve 66 causes the pneumatic counter 54 to advance by one and causes the discharge control valve 68 to change to position 2. As the transfer valve 62 is now in position 1, the vacuum from the venturi ejector 56 and the purge valve 60 has now been transferred to the first vessel 10 which subsequently begins to fill. The outlet port one way check valve 30 of the first vessel 10 is pulled closed by the vacuum whilst the inlet port check valve 26 is sucked open. Meanwhile, because the discharge control valve 68 is in position 2, an air supply is sent to the second vessel 12 via the transfer valve 62 causing the recovered fluid to discharge. The inlet one way check valve 28 of the second vessel 12 will be forced to close whilst the outlet check valve 32 will be forced to open due to the discharging fluid. The air supply

from the discharge control valve 68 is also supplied to the timer 70 which begins to charge by means of its reservoir 72.

Stage 5

After the pre-determined period, the reservoir 72 is full causing the timer 70 to move to position 2 as can be seen in Fig 7. The timer 70 sends a pilot signal to the discharge control valve 68 which then reverts back to position 1. This has the effect of resetting the timer 70 and stopping the air supply to the second vessel 12 which now should have all of its contents discharged. Because the timer 70 has reset itself, it now reverts back to position 1. This means that the pilot signals which were sent from float valve 36 of the second vessel 12 to the transfer valve 62 and the discharge control valve 68 will have exhausted to atmosphere. Whilst all of this is happening, the first vessel 10 currently being subjected to vacuum continues to fill. The cycle now repeats itself.

Manual Discharge

The entire operational cycle is completely automatic. However, once the operator has completed his spillage recovery task, he may wish to discharge the remainder of the contents held within either of the holding vessels 10, 12 of the apparatus. With reference to Fig 8, the purge valve 60 is pressed so that it changes to position 2. This has the effect of applying positive pressure to the vessel which is currently being subjected to vacuum (the first vessel 10 in this case). When all of the fluid has been discharged and the operator is finished, he can then release the button on purge valve 60 which returns to position 1. The

positive pressure ceases and vacuum is returned to the first vessel 10 (in this example). The main air supply 38 may then be removed from the apparatus at this time if the operator has finished his task.

A second, preferred embodiment of liquid recovery apparatus in accordance with the invention will now be described with reference to Figs. 9 to 19 of the drawings.

Fig. 9 shows the general arrangement of the second embodiment in twin vessel form. This is generally similar in structure and general working principle to the first embodiment, and like or equivalent features of the second embodiment are designated by reference numerals corresponding to those used in the first embodiment, prefixed "1".

The principal differences between the first and second embodiments are as follow:

(a) The first and second vessels 110 and 112 of the second embodiment each includes a second float valve 176, 178 located adjacent the bottoms of the vessels for detecting when the liquid level in the vessels falls to a predetermined minimum level. These float valves form part of the control means of the apparatus, in place of the timer 70 of the first embodiment, and have associated control lines connected to the control box 140.

(b) The inlet and outlet one way check valves 26, 28, 30, 32 of the first embodiment are replaced by pneumatically controlled valves 126, 128, 130, 132 in the second embodiment, with corresponding control lines connected to the control box 140.

The apparatus is again powered by compressed air and

pneumatically controlled.

There now follows a more detailed description of the working principle of the second embodiment of the invention, with reference to Figs. 10 to 19 of the drawings

The apparatus again gets its vacuum by means of a venturi ejector 156, as in the first embodiment.

The apparatus operates in a cyclical manner as shall now be described.

Stage 1 (Fig 10)

With reference to Fig 10, air is supplied and passes through the manual purge valve 160 and sends a pneumatic pilot signal to a venturi control valve 180 causing it to change position 2. Air from the purge valve 160 is also supplied to the venturi ejector 156 causing a vacuum to be created through the venturi control valve 180. The vacuum passes through the transfer valve 162 which is shown in position 1 allowing the vacuum to be applied to the first vessel 110. A suction/discharge line control valve 182 is synchronised with the transfer valve 162 such that the air supply on the suction/discharge line control valve 182 is in position 1 giving a valve open signal (VOS) to the inlet valve 126 of the first vessel 110 and the outlet valve 132 of the second vessel 112, and a valve close signal (VCS) to the outlet valve 130 of the first vessel 110 and the inlet valve 128 of the second vessel 112. As the operator applies the suction head 50 (Fig. 2) to the spillage 52, fluid is sucked via the inlet valve 126 into the first vessel 110 which then begins to fill. At this stage nothing else happens within the

rest of the apparatus.

Stage 2 (Fig 11)

As the first vessel 112 is now filling, the fluid level eventually forces the lower float valve 176 of the first vessel 110 to change over to position 2 as shown in Fig 11. This results in a pilot signal being sent to an AND valve 184. The AND valve 184 requires two input signals before an output pilot signal is generated. Therefore at this stage nothing else happens within the rest of the apparatus.

Stage 3 (Fig 12)

The first vessel 110 continues to fill until the fluid level reaches its upper float valve 134 causing this valve to change over to position 2 as shown in Fig 12. The upper float valve 134 sends a pilot signal to a first OR valve 186, making it change over to position 1. This allows the AND valve 184 to receive a second input signal letting it give an output pilot signal to the transfer valve 162, to a second OR valve 188 and to the suction/discharge line control valve 182 with each of these valves changing over to position 2. The air supply on the suction/discharge valve 182 is now changed over giving a valve close signal (VCS) to valves 126 and 132 and a valve open signal (VOS) to valves 130 and 128. Because the transfer valve 162 has also changed to position 2, vacuum has been transferred to the second vessel 112 which begins to fill with fluid via valve 128. Equally, a pressure discharge valve 190 has changed to position 2 due to the output pilot signal from the second OR valve 188. An air supply from the pressure discharge valve 190 also passes through the transfer valve 162 and is used to

pressurise the first vessel 110 causing the recovered fluid to be discharged into the discharge line 122 via valve 132. The discharging fluid also passes through a discharge line exit valve 192 which receives a valve open signal from the second OR valve 188. The air supply from the transfer valve 162 is also used as a pilot signal to a pressure sensing diaphragm valve 194 which changes to position 2 causing a further pilot signal to be sent to the first OR valve 188.

Stage 4 (Fig 13)

As the fluid level drops in the first vessel 110, the upper float valve 134 returns to position 1 as shown in Fig 13. However, because the first vessel 110 is still pressurised, the pressure sensing diaphragm valve 194 continues to send a pilot signal to the first OR valve 186 which changes to position 2 and hence the second signal to the AND valve 184 is maintained as is the pilot signal to the pressure discharge valve 190 which remains in position 2. Therefore, the first vessel 110 continues to be pressurised and the recovered fluid continues to discharge via valve 130 and discharge line exit valve 192. Meantime, the second vessel 112 continues to fill and the fluid level eventually forces the lower float valve 178 of the second vessel 112 to change over to position 2 as shown in Fig 13. This results in a pilot signal being sent to the second AND valve 196. The second AND valve 196 requires two input signals before an output pilot signal is generated.

Stage 5 (Fig 14)

Eventually the fluid level in the first vessel 110 falls low enough to allow its lower float valve 176 to change back to position 1 stopping one of the pilot

signals to the first AND valve 184 as shown in Fig 14. The pilot signals to the pressure discharge valve 190 and discharge line exit valve 192 are therefore ceased allowing the pressure discharge valve 190 to return to position 1 and discharge line exit valve 192 to close under its internal spring mechanism. The first vessel 110 ceases from being pressurised so that the pressure sensing diaphragm valve 194 returns to position 1. Discharge line exit valve 192 is required to prevent liquid in the discharge hose siphoning back into either of the vessels. Meantime, the second vessel 112 continues to fill.

Stage 6 (Fig 15)

The second vessel 112 continues to fill until the fluid level reaches its upper float valve 136 causing this valve to change over to position 2 as shown in Fig 15. The upper float valve 136 sends a pilot signal to a third OR valve 198 making it change over to position 1. This allows the second AND valve 196 to receive a second input signal letting it give an output pilot signal to the transfer valve 162, to the second OR valve 188 and to the suction/discharge line control valve 192, with each of these valves changing over to position 1. The air supply on the suction/discharge line control valve 182 is now changed over giving a valve close signal (VCS) to valves 130 and 128 and a valve open signal (VOS) to valves 126 and 132. Because the transfer valve 162 has also changed to position 1, vacuum has been transferred to the first vessel 110 which begins to fill with fluid via valve 114. Equally, the pressure discharge valve 190 has changed to position 2 due to the pilot signal from the second OR valve 188. At this stage, the pulse counter 154 increments by one indicating the completion of a cycle

of operation in which both the first and second vessels have been filled with recovered liquid. An air supply from the pressure discharge valve 190 also passes through the transfer valve 162 and is used to pressurise the second vessel 112 causing the recovered fluid to be discharged into the discharge line 122 via valve 132. The discharging fluid also passes through the discharge line exit valve 192 which receives a valve open signal from the second OR valve 188. The air supply from the transfer valve 162 is also used as a pilot signal to a second pressure sensing diaphragm valve 200 which changes to position 2 causing a further pilot signal to be sent to the third OR valve 198.

Stage 7 (Fig 16)

As the fluid level drops in the second vessel 112, its upper float valve 136 returns to position 1 as shown in Fig 16. However, because the second vessel 112 is still pressurised, the second pressure sensing diaphragm valve 200 continues to send a pilot signal to the third OR valve 198 which changes to position 2 and hence the second signal to the second AND valve 196 is maintained as is the pilot signal to the pressure discharge valve 190 which remains in position 2. Therefore, the second vessel 112 continues to be pressurised and the recovered fluid continues to discharge via valve 132 and discharge line exit valve 192.

Meantime, the first vessel 110 continues to fill and the fluid level eventually forces its lower float valve 176 to change over to position 2 as shown in Fig 16. This results in a pilot signal being sent to the first AND valve 184 which requires two input signals before an output pilot signal is generated.

Stage 8 (Fig 17)

Eventually the fluid level in the second vessel 112 falls low enough to allow its lower float valve 178 to change back to position 1 stopping one of the pilot signals to the second AND valve 196 as shown in Fig 17. The pilot signals to the pressure discharge valve 190 and discharge line exit valve 192 are therefore ceased allowing the pressure discharge valve 190 to return to position 1 and discharge line exit valve 192 to close under its internal spring mechanism. The second vessel 112 ceases from being pressurised so that the second pressure sensing diaphragm valve 200 returns to position 1. The first vessel 110 continues to fill.

The cycle now continues to repeat itself.

Manual Discharge (Figs 18 & 19)

The entire operational cycle is completely automatic. However, as in the first embodiment, once the operator has completed his spillage recovery task, he may wish to discharge the remainder of the contents held within either of the holding vessels of the apparatus. With reference to Fig 18, purge valve 160 is pressed momentarily so that it changes to position 2. This results in momentarily stopping the supply to venturi 156 and the pilot signal to the venturi control valve 180. At the same time positive pressure is sent via the transfer valve 162 to the first vessel 110 which was on its suction cycle. The first AND valve 184 will give an output signal forcing the transfer valve 162, the second OR valve 198 and the suction/discharge line control valve 182 to change over to position 2. The air supply on the suction/discharge line control valve 182 is now changed over giving a valve close signal

(VCS) to valves 126 and 132 and a valve open signal (VOS) to valves 130 and 128.

At this stage the manual purge valve 160 will have been released and will have gone back to position 1. Because the transfer valve 162 has also changed to position 2, vacuum has been transferred to the second vessel 112 as shown in Fig 19. Equally, the pressure discharge valve 190 has changed to position 2 due to the output pilot signal from the second OR valve 188. An air supply from the pressure discharge valve 190 also passes through the transfer valve 160 and is used to pressurise the first vessel 110 causing the recovered fluid to be discharged into the discharge line 120 via valve 130. The discharging fluid also passes through the discharge line exit valve 192 which receives a valve open signal from the second OR valve 188. Assuming that the operator does not place the suction head in any other spillage then no other fluids will be recovered.

A third embodiment of the invention will now be described with reference to Figs. 20 and 21 of the drawings. This embodiment is a preferred modification of the second embodiment but incorporates improvements and simplifications of the control arrangements. Features of the third embodiment common to or equivalent to features of the second embodiment are designated by like reference numerals prefixed "2" instead of "1".

The third embodiment employs upper and lower float valves 234, 236, 276 and 278 in each of the vessels 210 and 212 as in the second embodiment. The various valves which control the operation of the apparatus differ in certain respects as follow:

(a) The inlet and outlet valves 226, 228, 230 and 232 are of the spring-loaded, normally closed type. This eliminates spillage of fluid in transit, dispenses with the need for separate control lines and associated control valves to close the valves during the cyclic operation of the apparatus, and allows the exit line discharge valve 192 of the second embodiment to be dispensed with.

(b) The transfer valve 262 which switches the vacuum between the vessels is of the ball valve type with an actuator which minimises the changeover delay.

(c) The vessels each have a safety pressure release valve 300, 302; a pressure exhausting valve 304, 306 for venting residual pressure following discharge of liquid from the respective vessel 210 or 212 and closure of the respective discharge valve 230 or 232; and a pressure discharge valve 308, 310, corresponding to the single pressure discharge valve 190 of the second embodiment, for pressurising the respective tanks to discharge liquid therefrom.

(d) The outputs of the float valves 234, 236, 276, 278 are connected to control valves 312, 314 and 316. The uppermost valve 312 operates in response to the upper float valves 234, 236 and controls the ball valve 262 to switch the vacuum between the vessels 210, 212. The lower control valves 314, 316 operate in response to the lower float valves 276, 278 of the vessels 210 and 212 respectively during discharge of liquid. When the liquid in the relevant vessel falls below the float valve level, the corresponding control valve 314 or 316 operates to allow the corresponding discharge valve 230 or 232 to close and to cause the corresponding pressure exhaust valve 304 or 306 to open. Once open, the pressure exhaust valve 304 or 306 remains open until the vacuum is reapplied to the corresponding vessel 210 or 212.

(e) The air supply 238 is connected to the apparatus via a main valve 318 which controls the main air supply to the venturi pump 256, via its integral control valve 280, and which includes the manual purge valve (omitted from Fig. 21 for clarity) for manual discharge of liquid from the vessels. In this case, manual purging results in one vessel being purged prior to the other, as a result of the use of the ball valve 262 which always connects the venturi pump 256 to one or other of the vessels at any given time.

The apparatus of the third embodiment operates in a cyclic manner similar to the second embodiment, the transfer of the vacuum between the vessels being effected by the ball valve 262 and controlled by the operation of the upper and lower float valves in response to the liquid level rising and falling in the vessels as before.

Figs. 22 to 24 illustrate a suitable physical arrangement of the components of the apparatus. The illustrated example corresponds particularly to the third embodiment, however a similar general arrangement may be employed for the first and second embodiments.

The liquid holding vessels 210 and 212 have a generally upright cylindrical configuration and are disposed side by side, connected via conduits 242, 244 to the transfer valve 262, which has an associated actuator 324. The venturi vacuum unit 256 is mounted to the rear of the transfer valve 262. The control panel 240 is mounted in front of the transfer valve 262, to one side of the apparatus. The vessel inlets 214, 216 extend outwardly from the front of the vessels 210, 212 and are connected to the common inlet conduit 218, in this example, via a filter 320. Whilst an inlet filter is

not strictly necessary in view of the absence of moving parts inside the vessels 210, 212, its use may be desirable in some circumstances or may be required by applicable technical standards.

The safety pressure release valves 300, 302, pressure exhaust valves 304, 306 and pressure discharge valves 308, 310 of Fig. 21 are omitted from Figs. 22 to 24 for clarity, but may suitably be mounted on three limbs of two respective cross pieces, one of which is mounted on each of the conduits 242 and 244 connecting the ball valve 262 to the respective vessels 210 and 212.

Outlets 220, 222 extend outwardly from the front of the vessels 210, 212 below the inlets 214, 216, and are connected to the common discharge line 224.

The apparatus may be mounted within a generally rectangular open frame 322.

Whilst the invention has been described in relation to embodiments having two liquid holding vessels, it will be appreciated that the invention might also be applied to embodiments having more than two vessels, the control mechanisms being modified as appropriate.

It will be further appreciated that the arrangement of upper and lower float valves in the second and third embodiments of the invention might also be advantageously applied to liquid recovery apparatus of the type having a single liquid holding vessel, as disclosed in EP-B-0 162 074, allowing the timer of such apparatus to be dispensed with and providing improved efficiency of operation.

The advantages of the present invention and the ways in

which the disadvantages of previously known arrangements, as discussed in the introductory part of the present description, are overcome include the following:-

The disadvantage of alternate vacuum and discharge is overcome by the fact that this invention operates a dual holding vessel system. When one vessel is full of recovered fluid, the vacuum is switched to the second vessel whilst the first one discharges. Therefore vacuum is never lost. This will be more convenient to the operator.

The disadvantage of fluctuating (sinusoidal) vacuum/discharge is overcome by virtue of suction in the apparatus being created by a venturi ejector principle. This is the more favoured method by operators. It is also more reliable as there are no moving parts.

The disadvantage of discharge pumps being damaged due to debris and suction line filters being removed is overcome by the fact that the apparatus has virtually no moving parts in contact with the recovered fluid.

The disadvantage of high service down time is overcome due to the simplicity of the apparatus, its modern pneumatic control system, and the fact that it has virtually no moving parts.

The disadvantage of a time giving too long a discharge time for low viscosity fluids and too short a discharge time for high viscosity fluids is overcome because the upper and lower float valves in each vessel which determine how long the pressurising discharge cycle should be.

That is, in its preferred form, the invention provides continuous vacuum in operation, venturi suction, minimal moving parts, low service downtime, no requirement for a suction filter, a simple control system, and a self-determining discharge cycle period. None of the existing types of liquid recovery apparatus discussed previously provide all of these features.

Claims

1. Apparatus for recovering liquids, comprising at least first and second vessels for liquid, vacuum pump means for applying a vacuum selectively to the first and second vessels, each vessel having an inlet for recovered liquid which includes valve means restricting liquid exit from the vessel, and an outlet through which liquid is discharged from the vessel, the outlet including valve means which restricts liquid entry to the vessel, and a conduit connected to said inlets to convey recovered liquid to the vessels.

2. Apparatus as claimed in Claim 1, further including control means including switching means adapted to switch the applied vacuum from one vessel to the other in response to a control signal indicating that the liquid level in said one container has reached a predetermined maximum level and to cause the liquid collected in said one container to be discharged via said outlet of said one vessel.

3. Apparatus as claimed in Claim 2, wherein said control means is adapted to apply said vacuum is alternately to said first and second vessels in a cyclical manner such that recovered liquid is drawn into one of the vessels via its inlet whilst any previously recovered liquid is discharged from the other vessel via its outlet, the vacuum being switched from said one vessel to said other vessel when the recovered liquid in said one vessel rises to said predetermined level, such that recovered liquid is drawn into said other vessel whilst the previously recovered liquid is discharged from said one vessel.

4. Apparatus as claimed in Claim 2 or Claim 3 wherein

said control means comprises pneumatic control means.

5. Apparatus as claimed in Claim 2, wherein said control signal is generated by first liquid level sensors located in each of said vessels.

6. Apparatus as claimed in Claim 2, wherein said sensors comprise float valves.

7. Apparatus as claimed in any preceding Claim, wherein said vacuum pump comprises a venturi ejector type pump.

8. Apparatus as claimed in any preceding Claim, wherein the valve means of said inlets and outlets comprise on way check valves.

9. Apparatus as claimed in any one of Claims 1 to 6, wherein the valve means of said inlets and outlets comprise pneumatically actuated valves.

10. Apparatus as claimed in Claim 8 wherein said pneumatically actuated valves are normally closed valves.

11. Apparatus as claimed in Claim 2 or Claim 3, wherein the period during which liquid is discharged from said one vessel is determined by timer means.

12. Apparatus as claimed in Claim 3, wherein said control means is further adapted to cause a pressure to be applied alternately to the interiors of said first and second vessels when recovered liquid is to be discharged therefrom.

13. Apparatus as claimed in Claim 12, wherein said

control means is further adapted to cause said pressure to be applied to the interior of said one vessel when the liquid level in said one vessel reaches said first level.

14. Apparatus as claimed in Claim 2 or Claim 3 wherein, said control means is further adapted to cause said inlet valve means of said one vessel to close, said outlet valve means of said one vessel to open, said inlet valve means of said other vessel to open and said outlet valve means of said other vessel to close when the liquid level in said one vessel reaches said first level.

15. Apparatus as claimed in Claim 5 wherein said first and second vessels each includes second level detector means for detecting when the level of recovered liquid in the vessel falls below a second, lower, predetermined level.

16. Apparatus as claimed in Claim 15 wherein said control means is further adapted to apply a pressure to the interior of said one vessel while liquid is being discharged therefrom and to remove said applied pressure from said one vessel when the liquid level in said one vessel falls below said second level.

17. Apparatus as claimed in any preceding Claim, wherein said outlets of said first and second vessels are connected to a common discharge conduit, said discharge conduit including discharge valve means.

18. Apparatus as claimed in Claim 17, wherein said control means is further adapted to cause said discharge valve means to close when the liquid level in said one vessel falls below a lowermost predetermined

level and to open when the liquid level in said other vessel exceeds an uppermost predetermined level.

19. Apparatus as claimed in Claim 3, further including counter means adapted to be incremented at a predetermined point in the cyclical operation of the apparatus.

20. Apparatus as claimed in Claim 19, wherein said counter means is incremented when the vacuum is switched from one of said first and second vessels to the other.

21. Apparatus as claimed in any preceding Claim, further including manually operable control means whereby recovered liquid may be discharged from said first and/or second vessels.

22. Apparatus for recovering liquids, comprising at least a first vessel for liquid, vacuum pump means for applying a vacuum selectively to said at least one vessel, said at least one vessel having an inlet for recovered liquid which includes valve means restricting liquid exit from the vessel, and an outlet through which liquid is discharged from the vessel, the outlet including valve means which restricts liquid entry to the vessel, and a conduit connected to said inlets to convey recovered liquid to the vessel, and further including first liquid level detecting means for detecting when the liquid level in said at least one vessel reaches an uppermost predetermined level and second liquid level detecting means for detecting when the liquid level in said at least one vessel reaches a lowermost predetermined level, and control means responsive to said first and second level detecting means and adapted to remove said vacuum from said at

least one vessel and to cause liquid contained therein to be discharged from said vessel when said liquid level reaches said uppermost predetermined level and to cause said vacuum to be reapplied to said vessel when said liquid level falls to said lowermost predetermined level.

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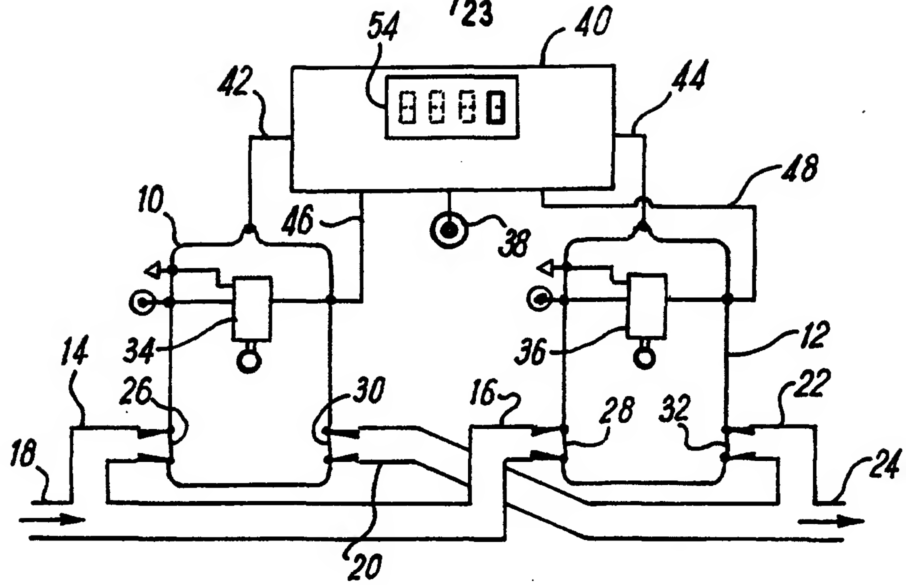

FIG. 1

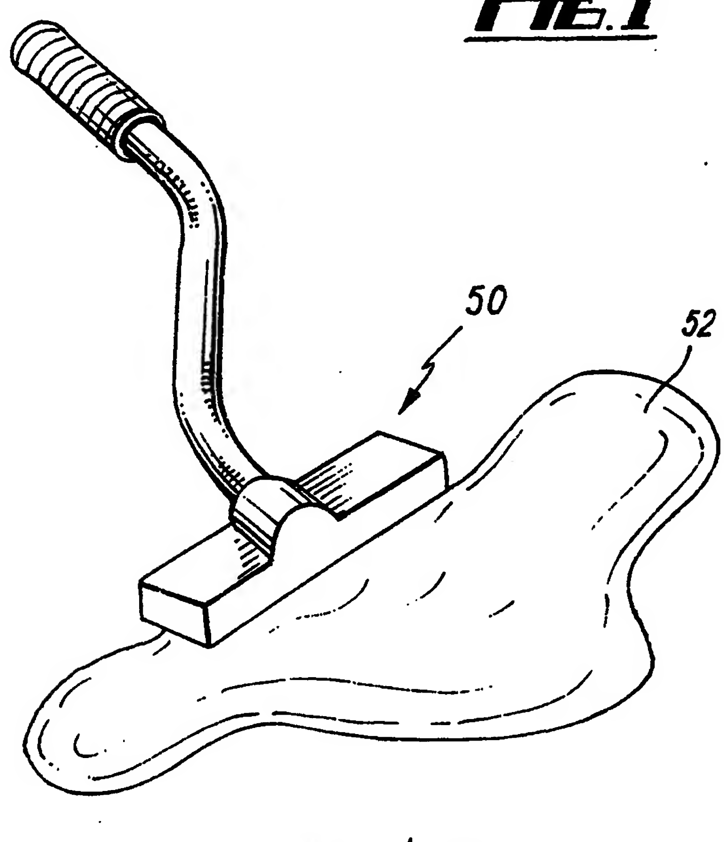

FIG. 2

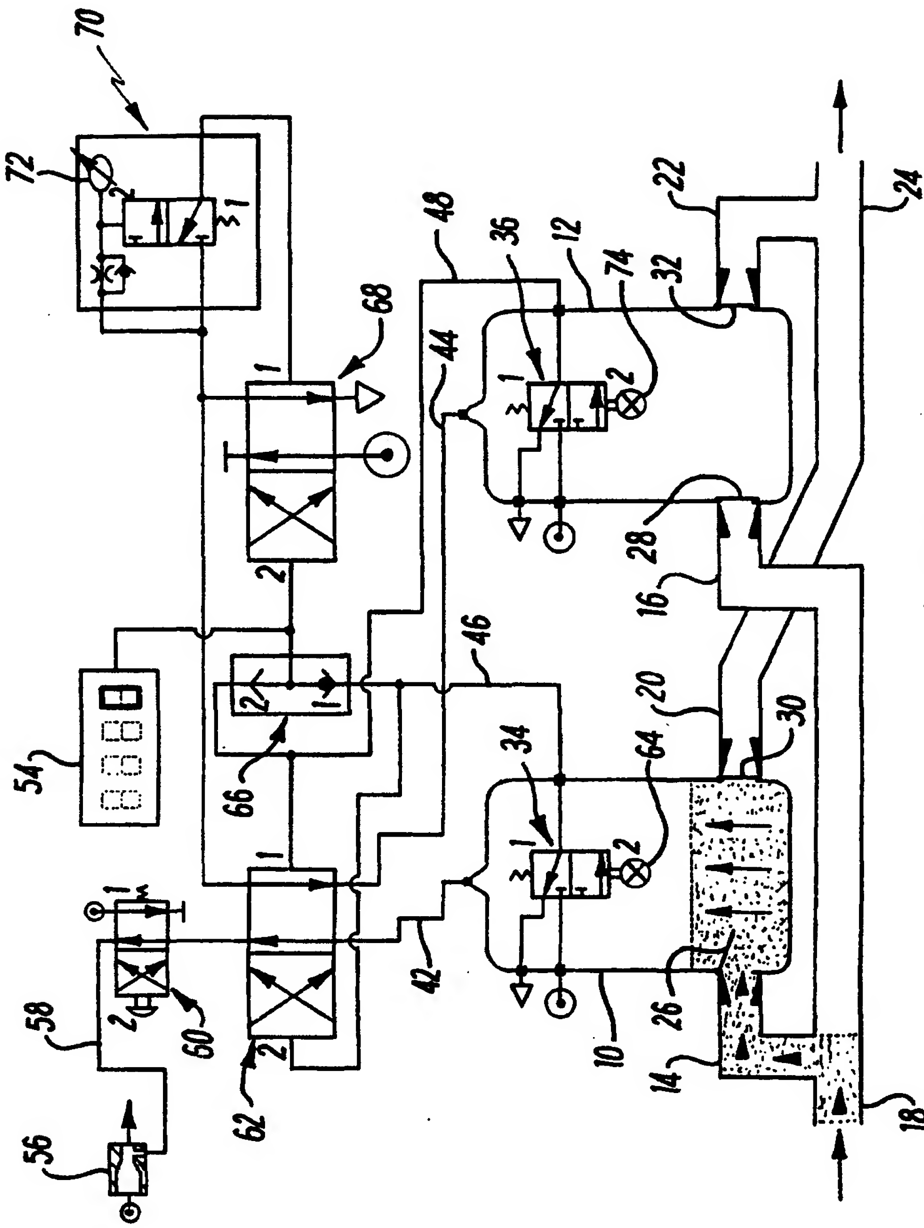
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FIG. 3

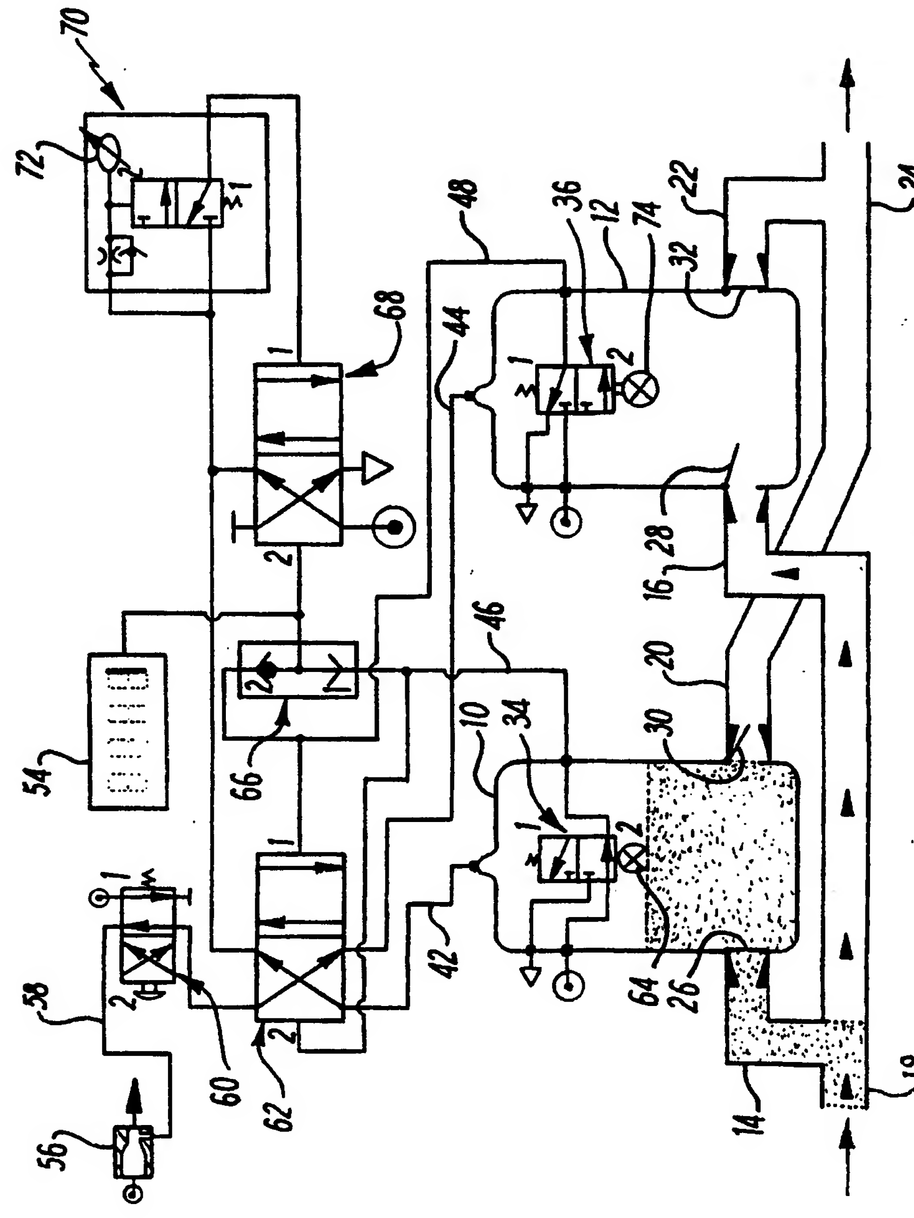
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FIG. 4

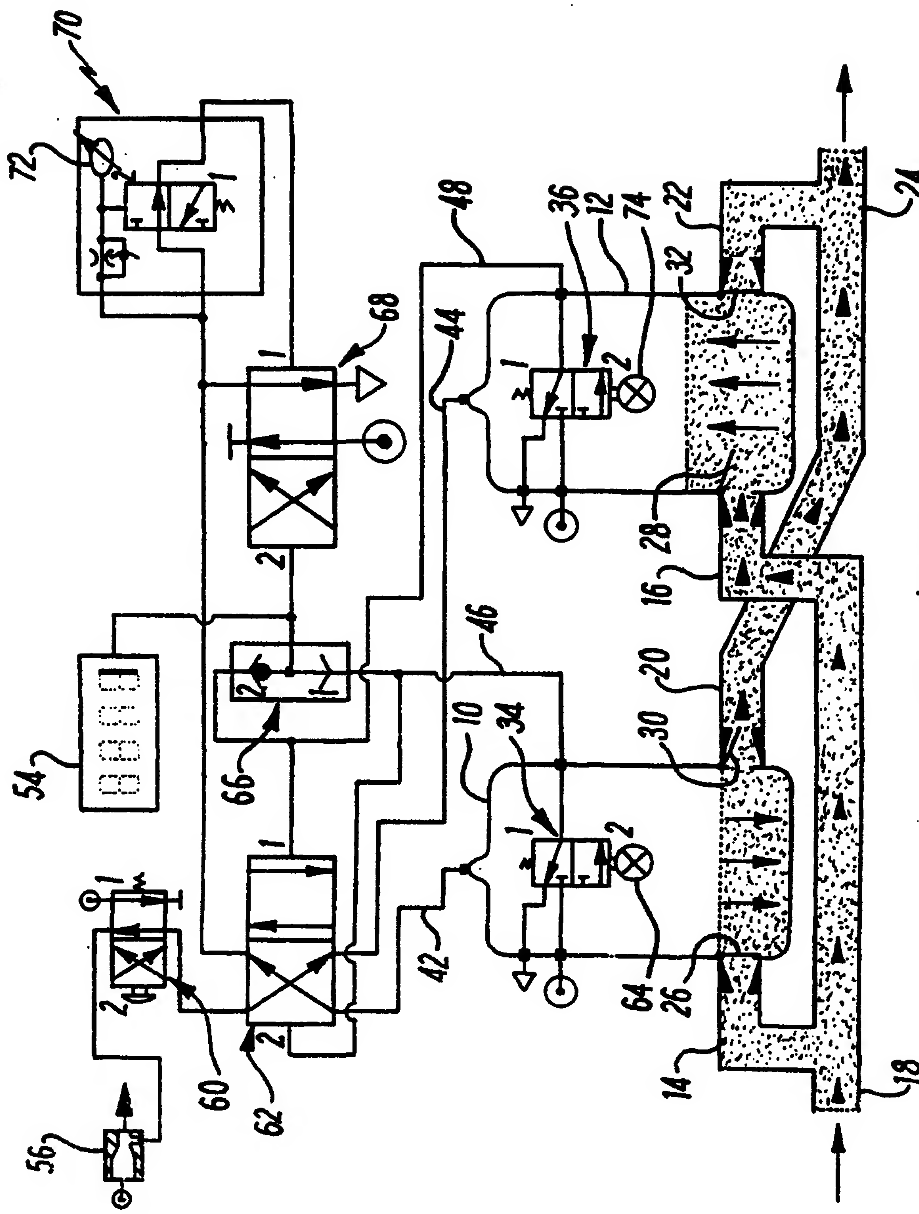
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Fig. 5

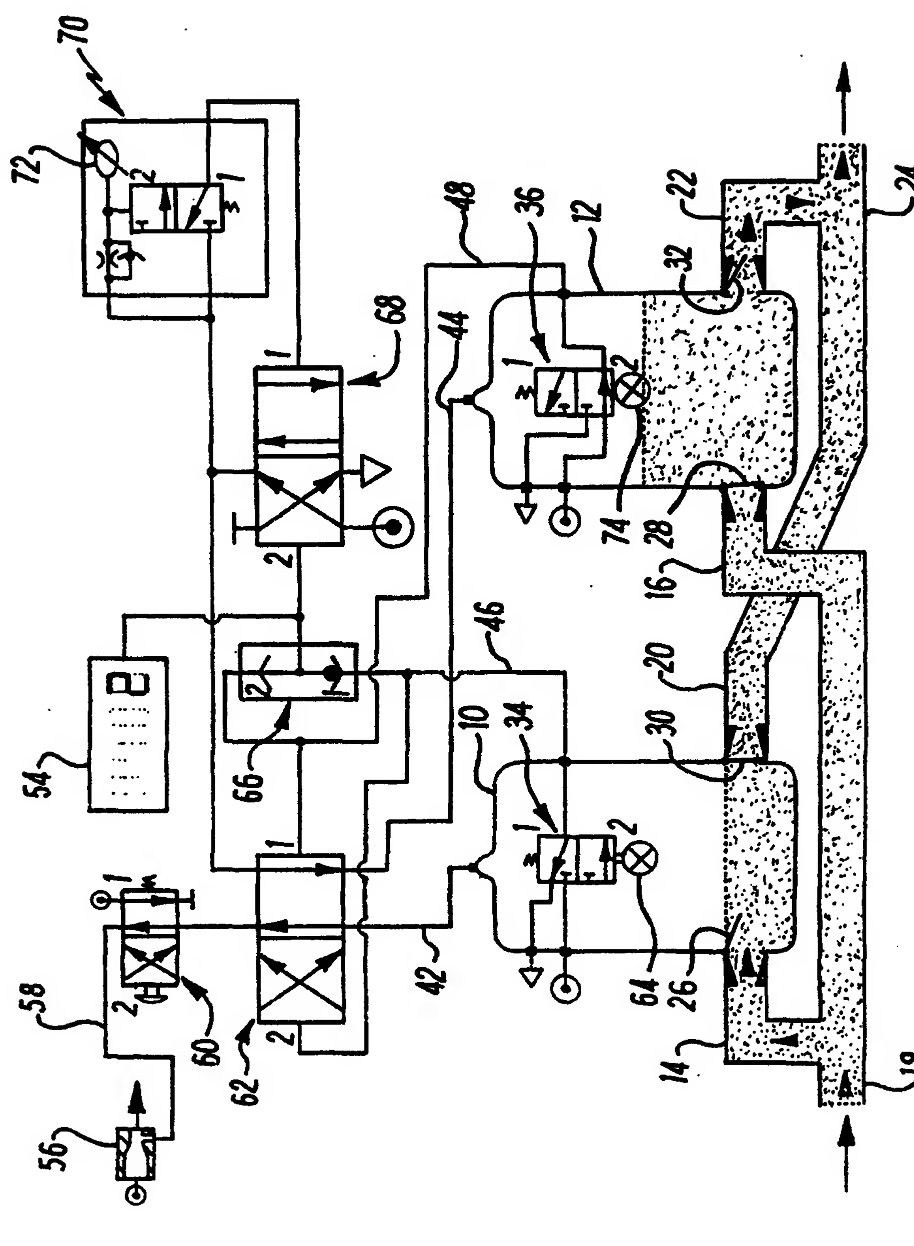
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Fig. 6

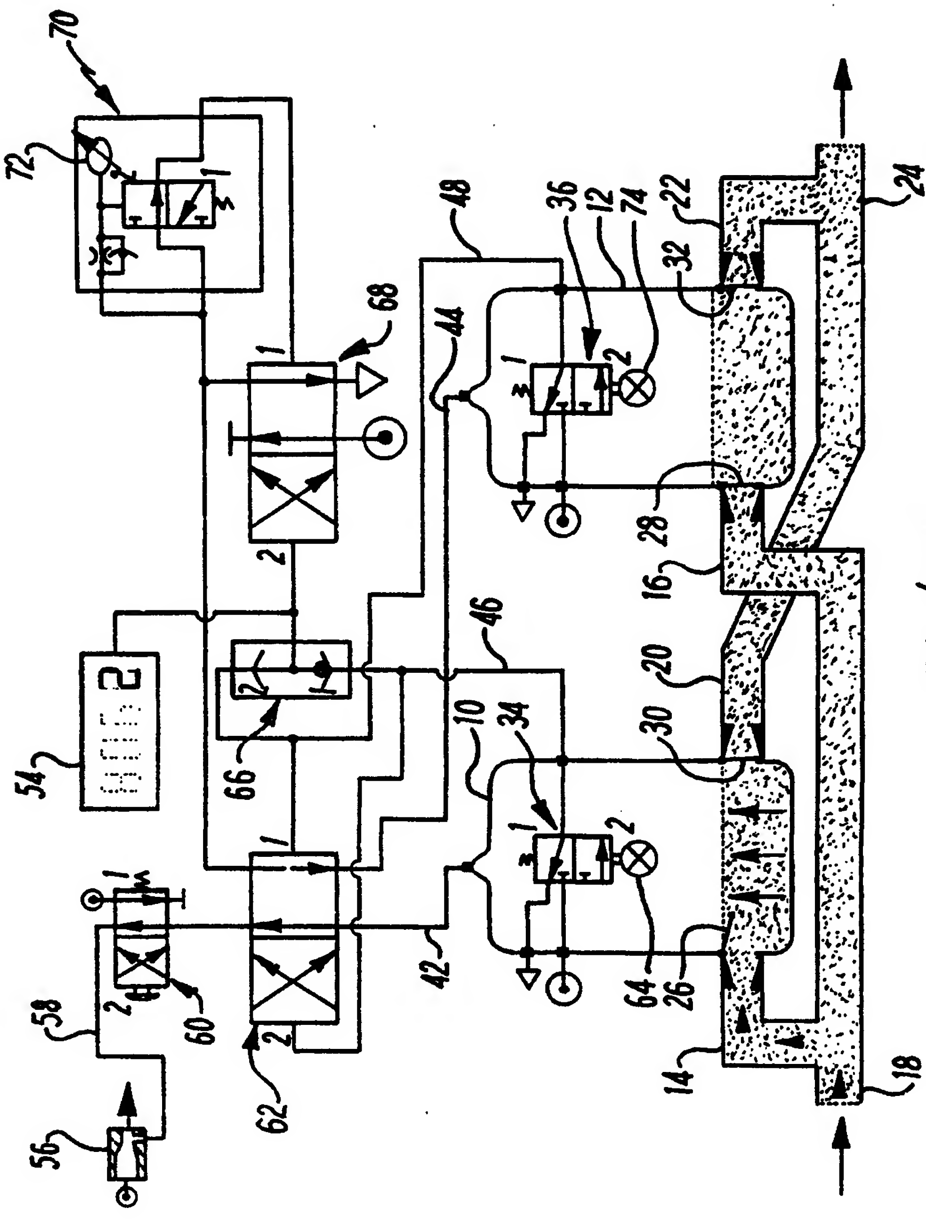

FIG. 7

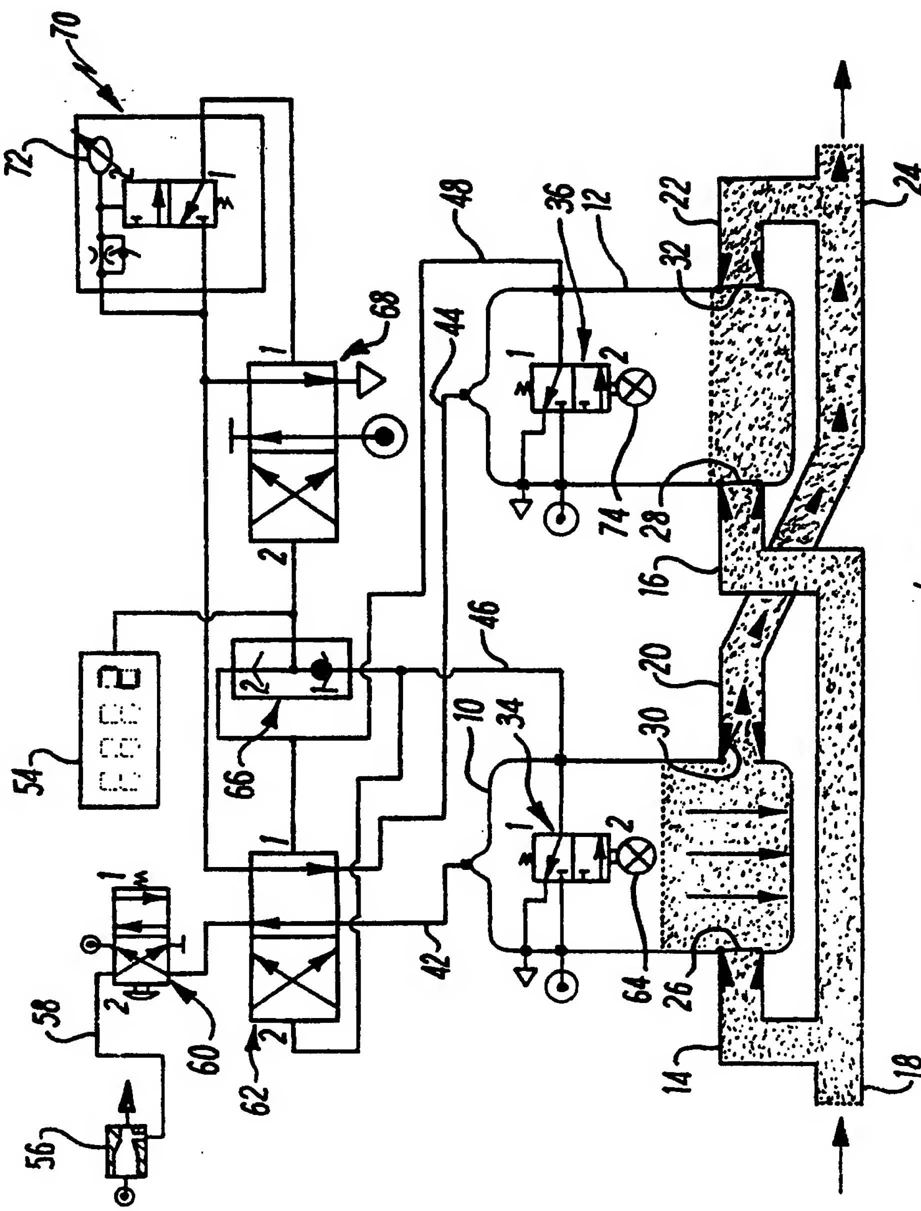

FIG. 8

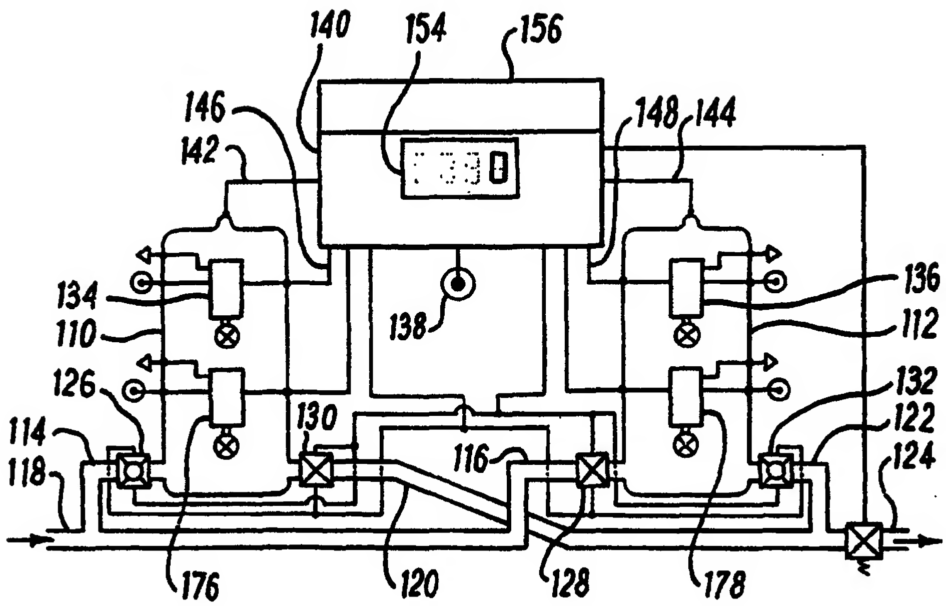
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FIG. 9

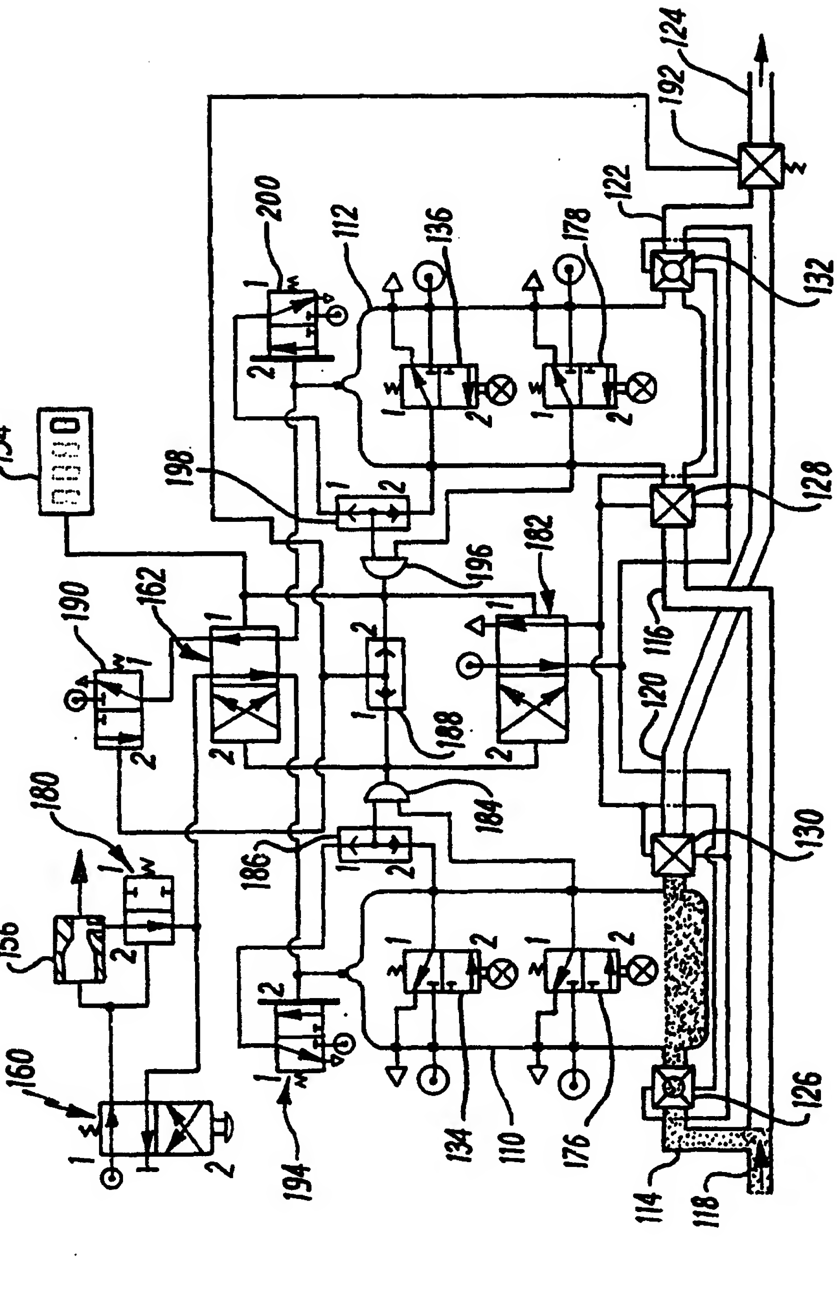
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FIG. 10

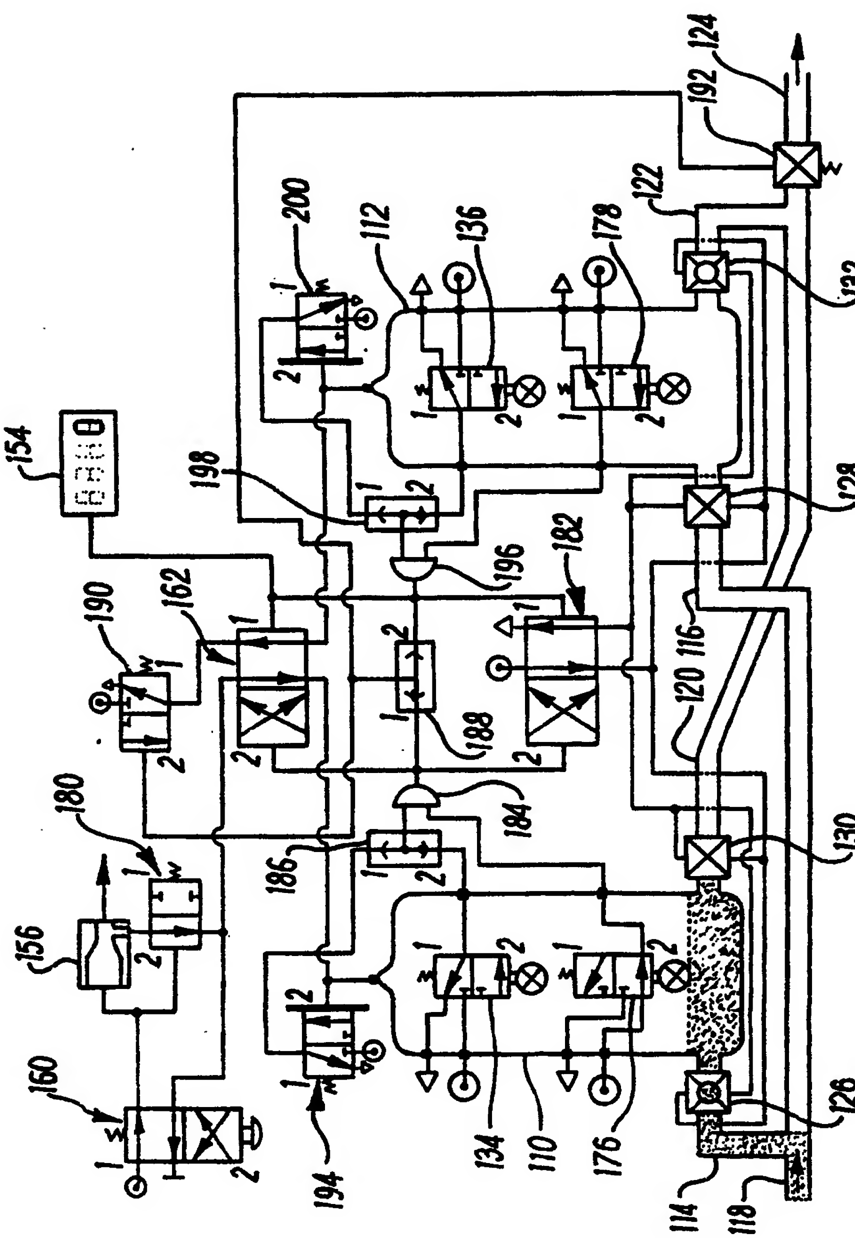

FIG. 11

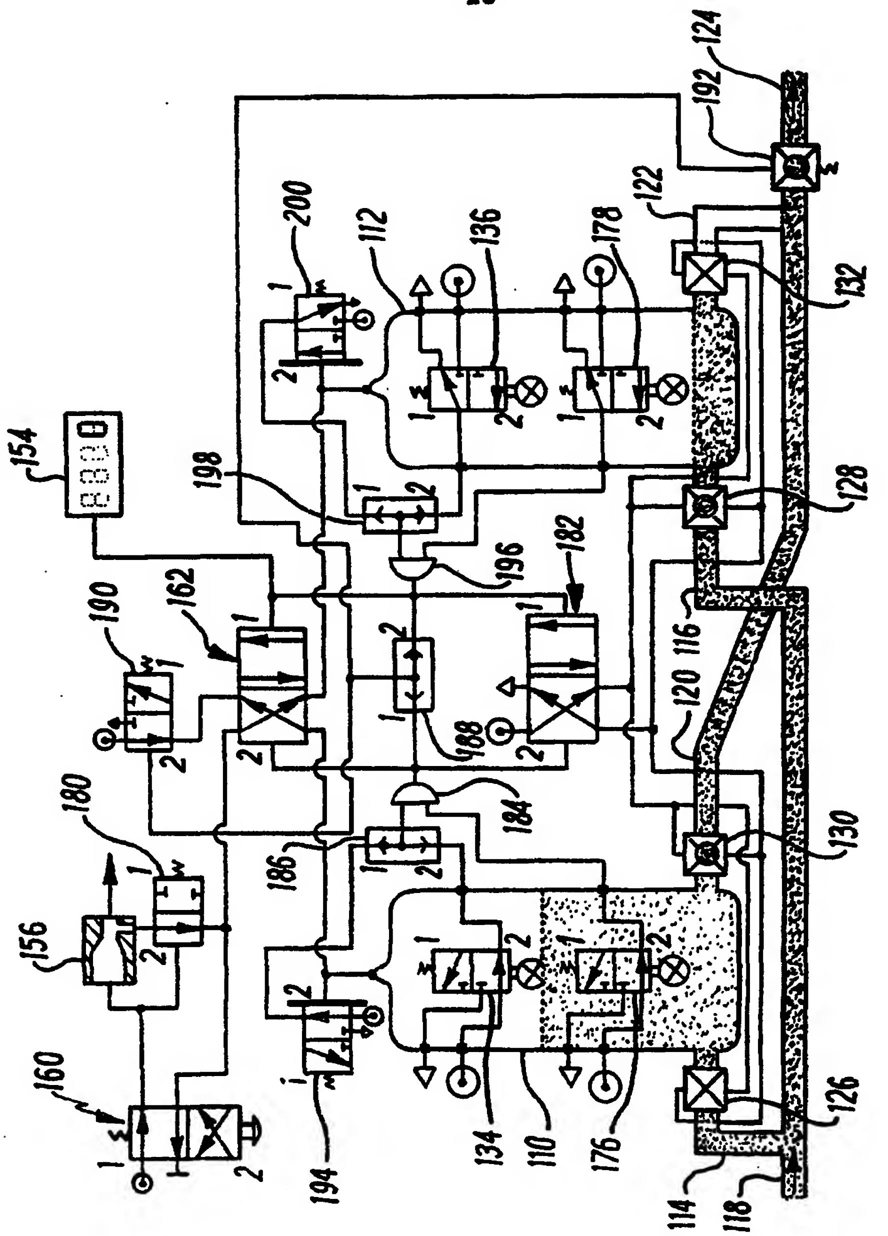

FIG. 12

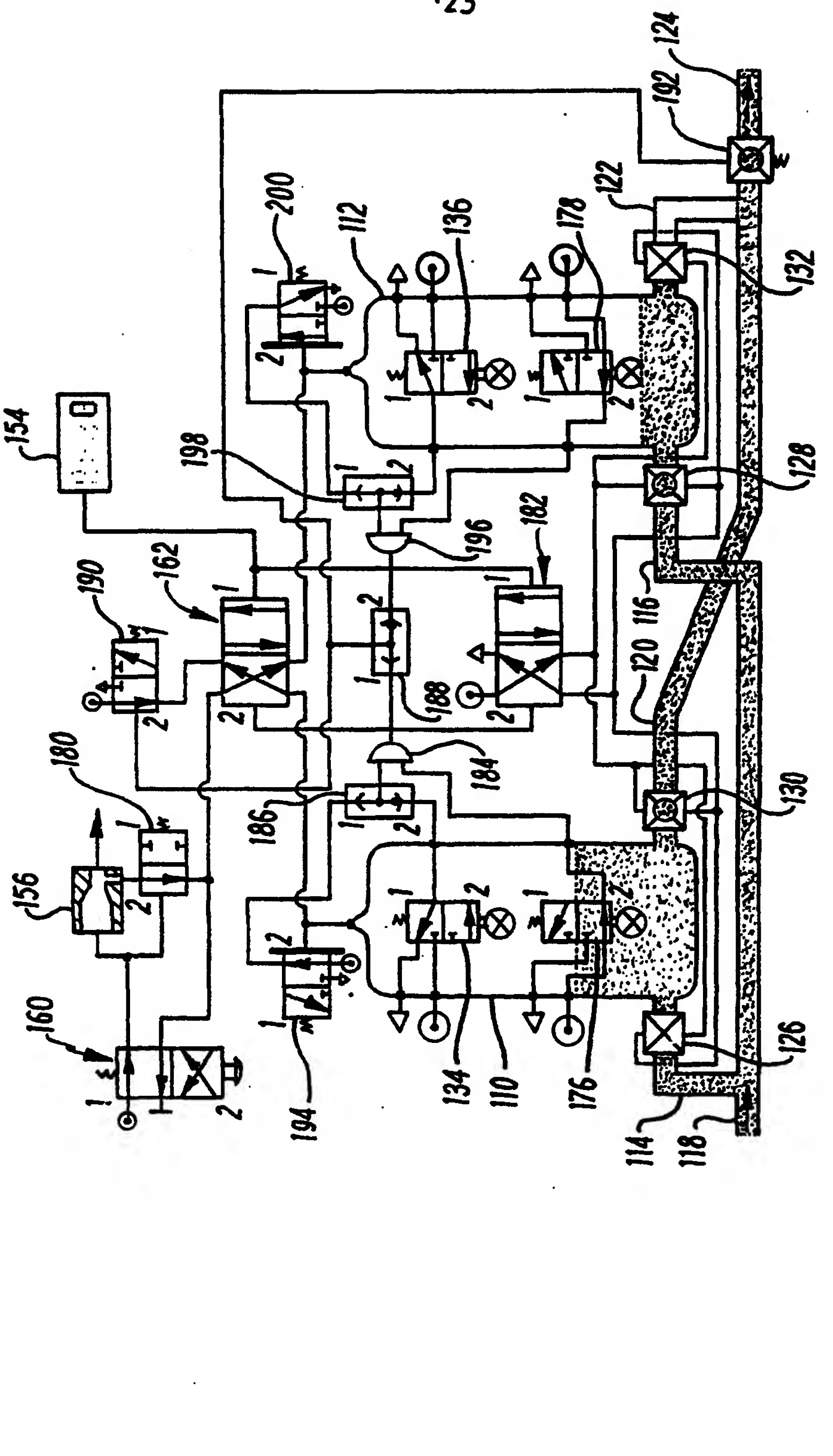

Fig.13

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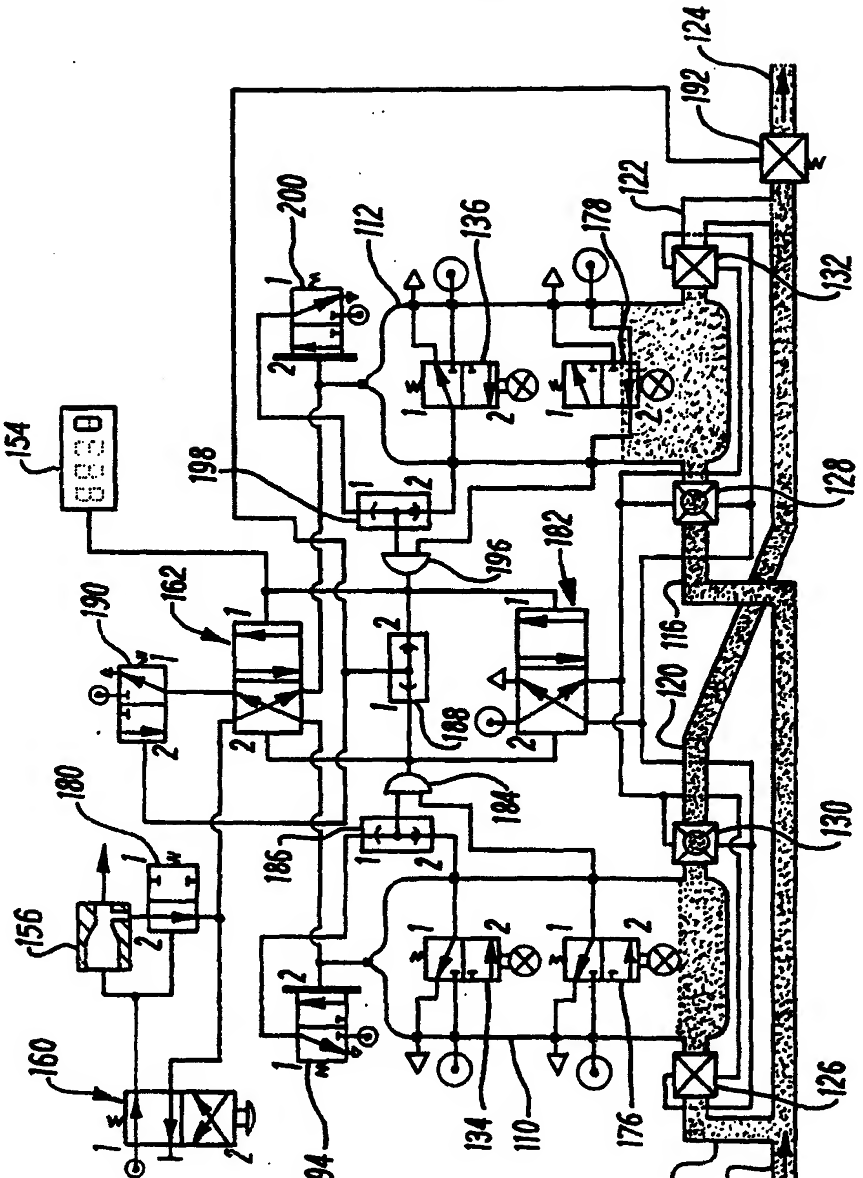
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FIG. 14

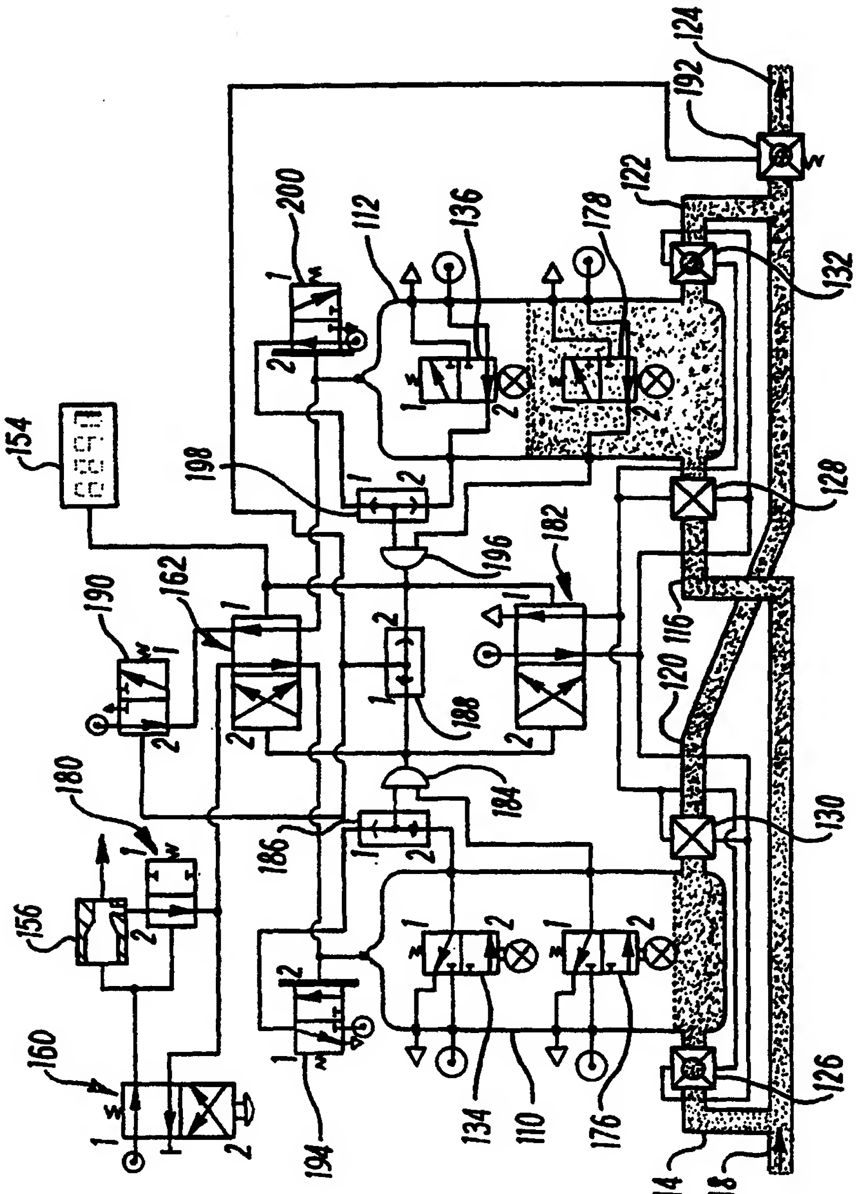
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FIG. 15

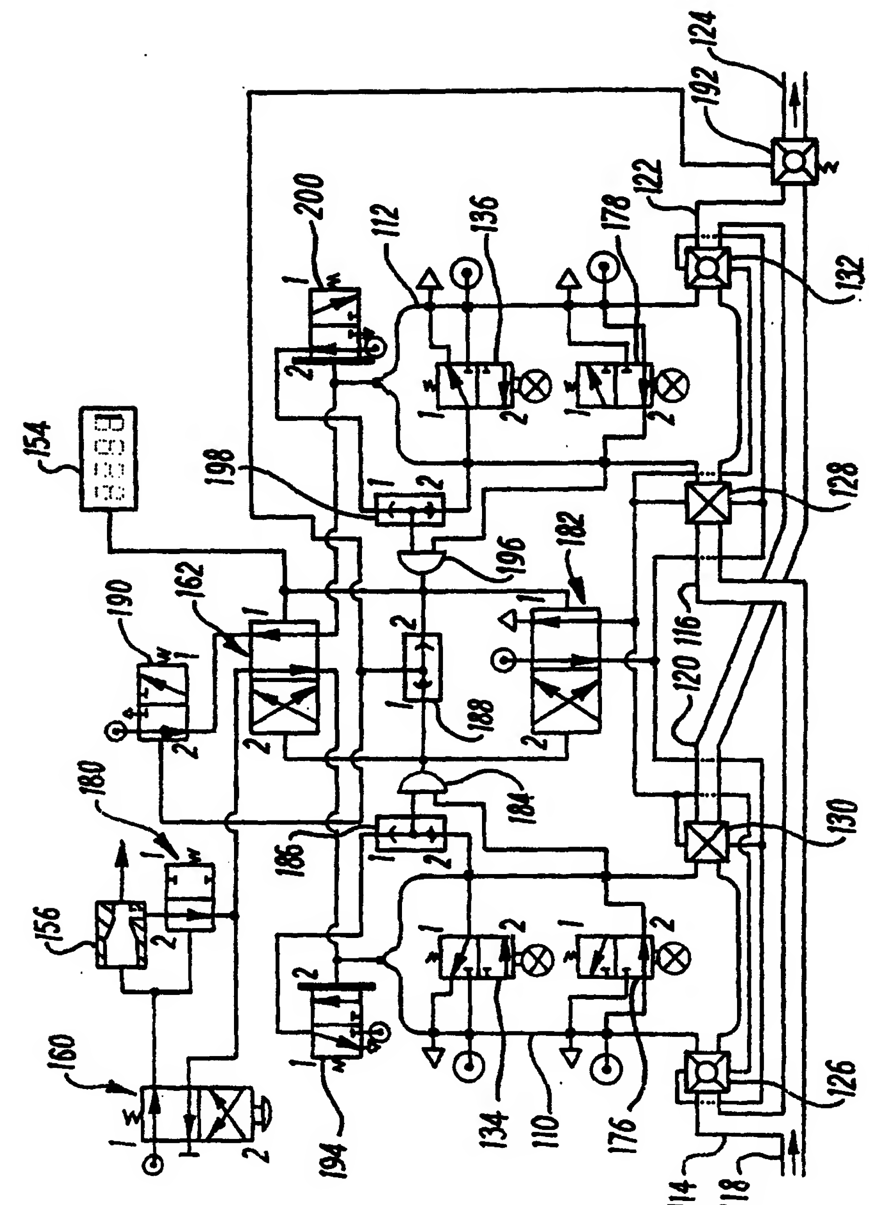

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FIG.16

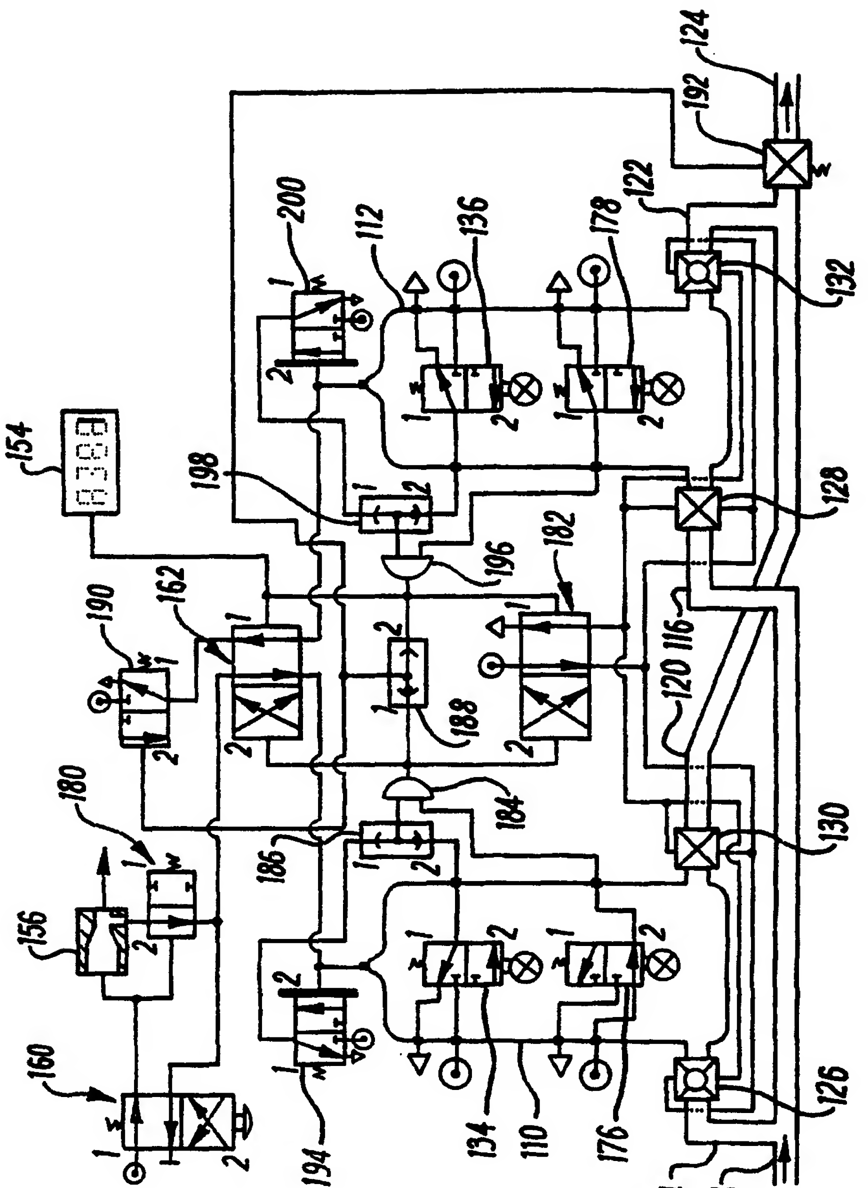
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FIG. 17

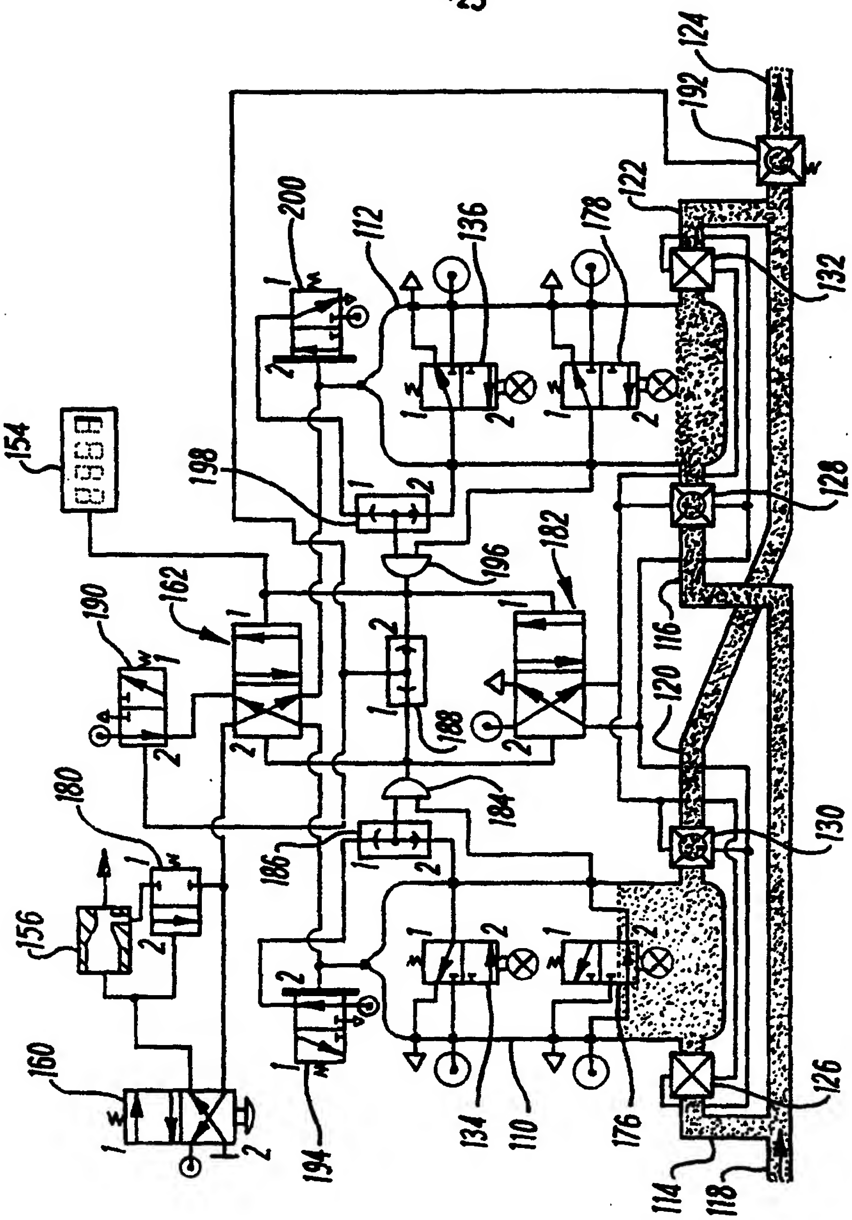
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FIG.18

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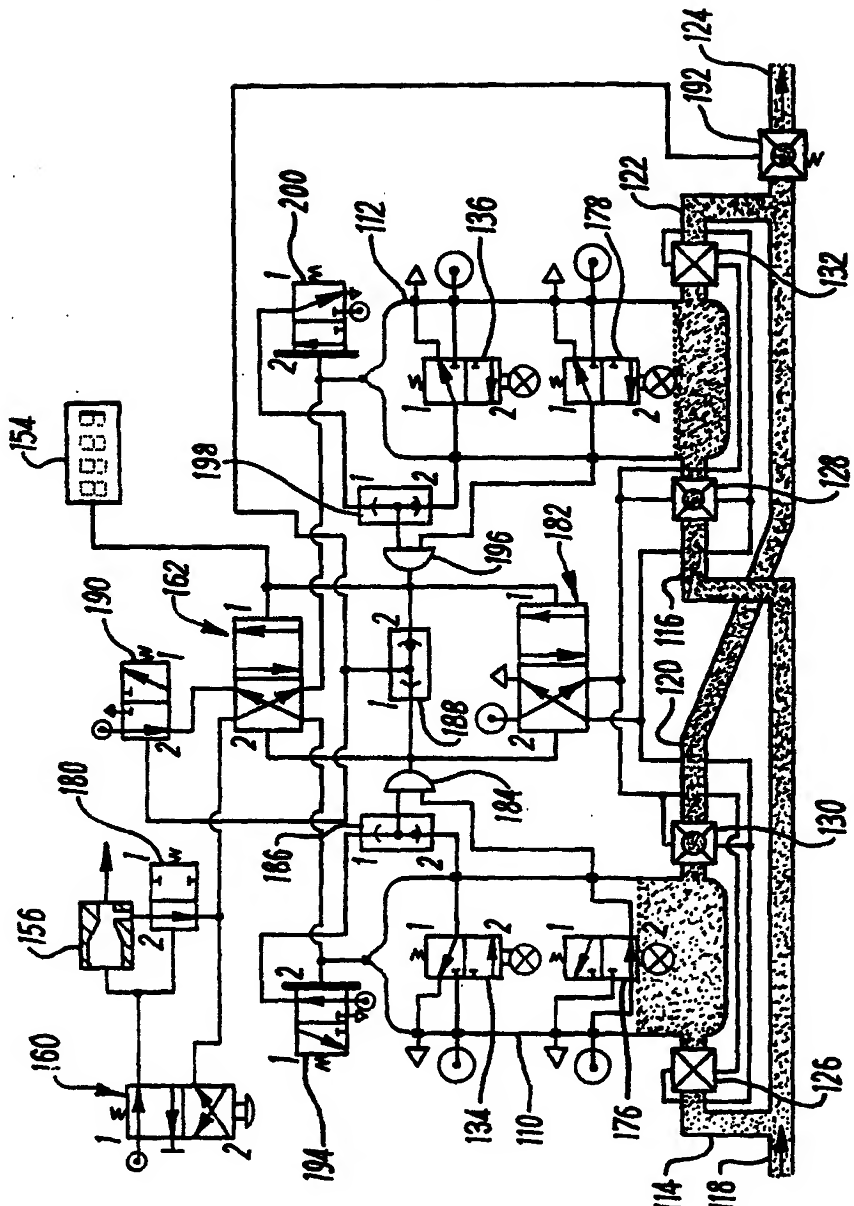
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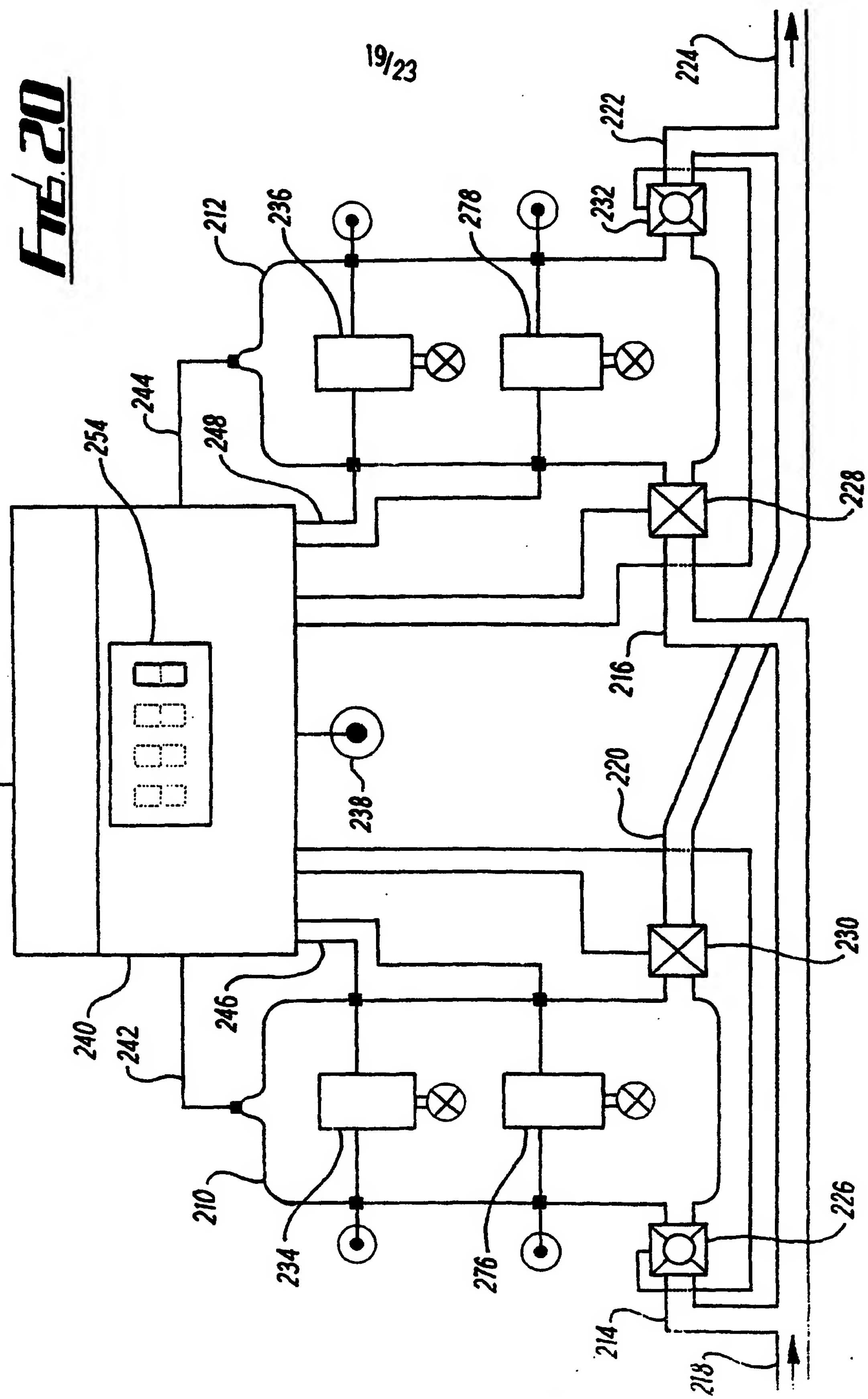
Fig.19

FIG. 20



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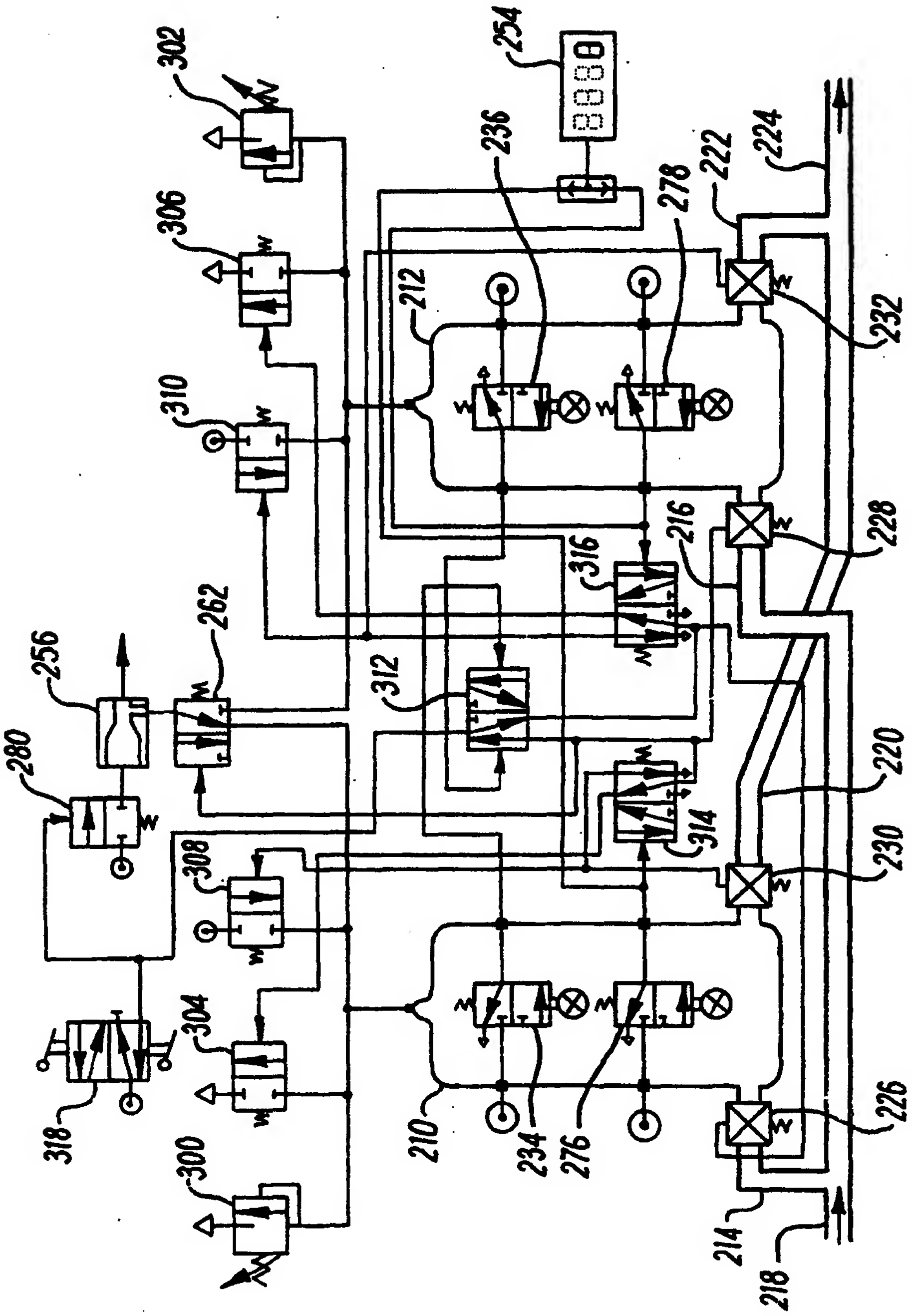
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FIG. 21

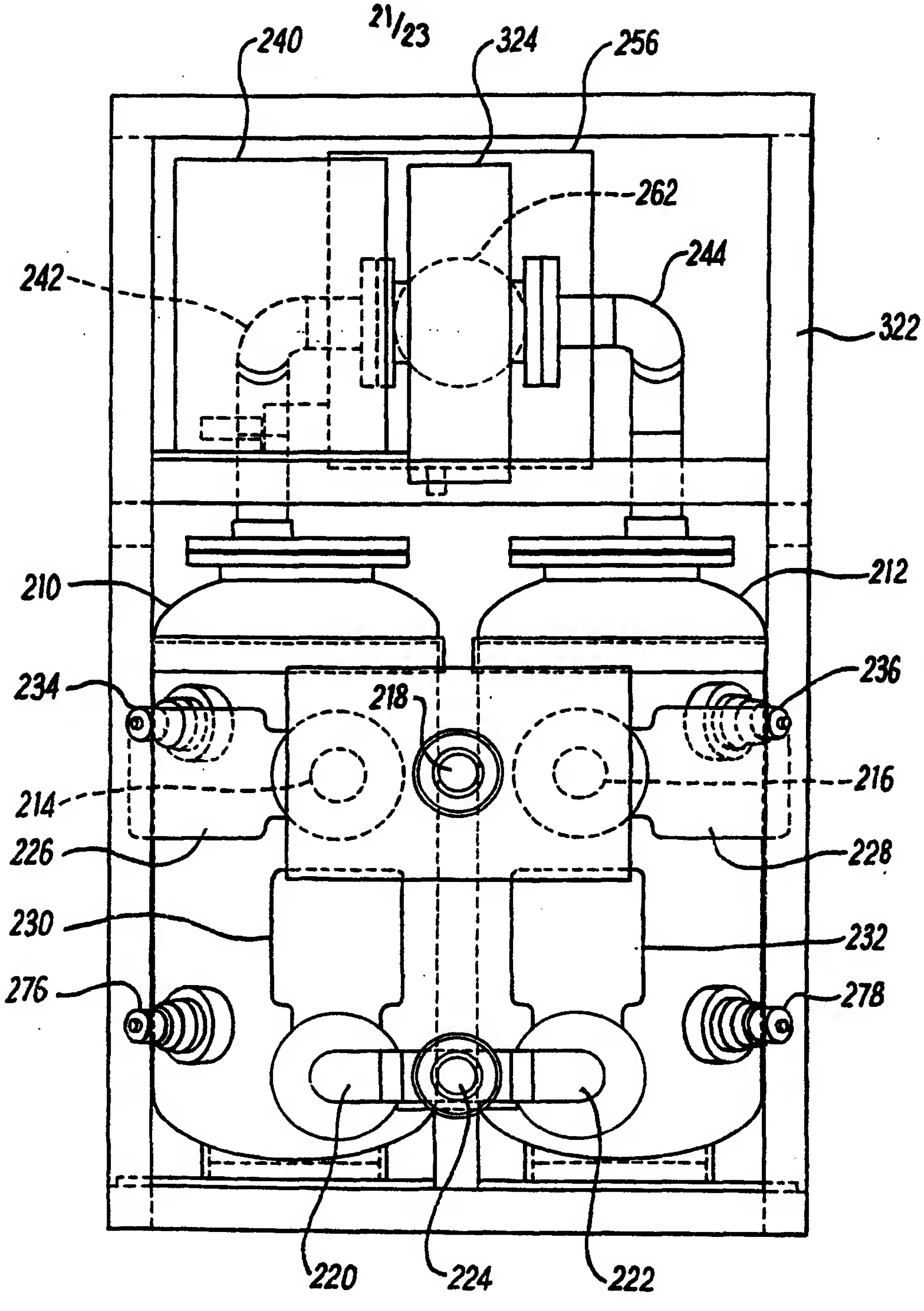
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FIG. 22

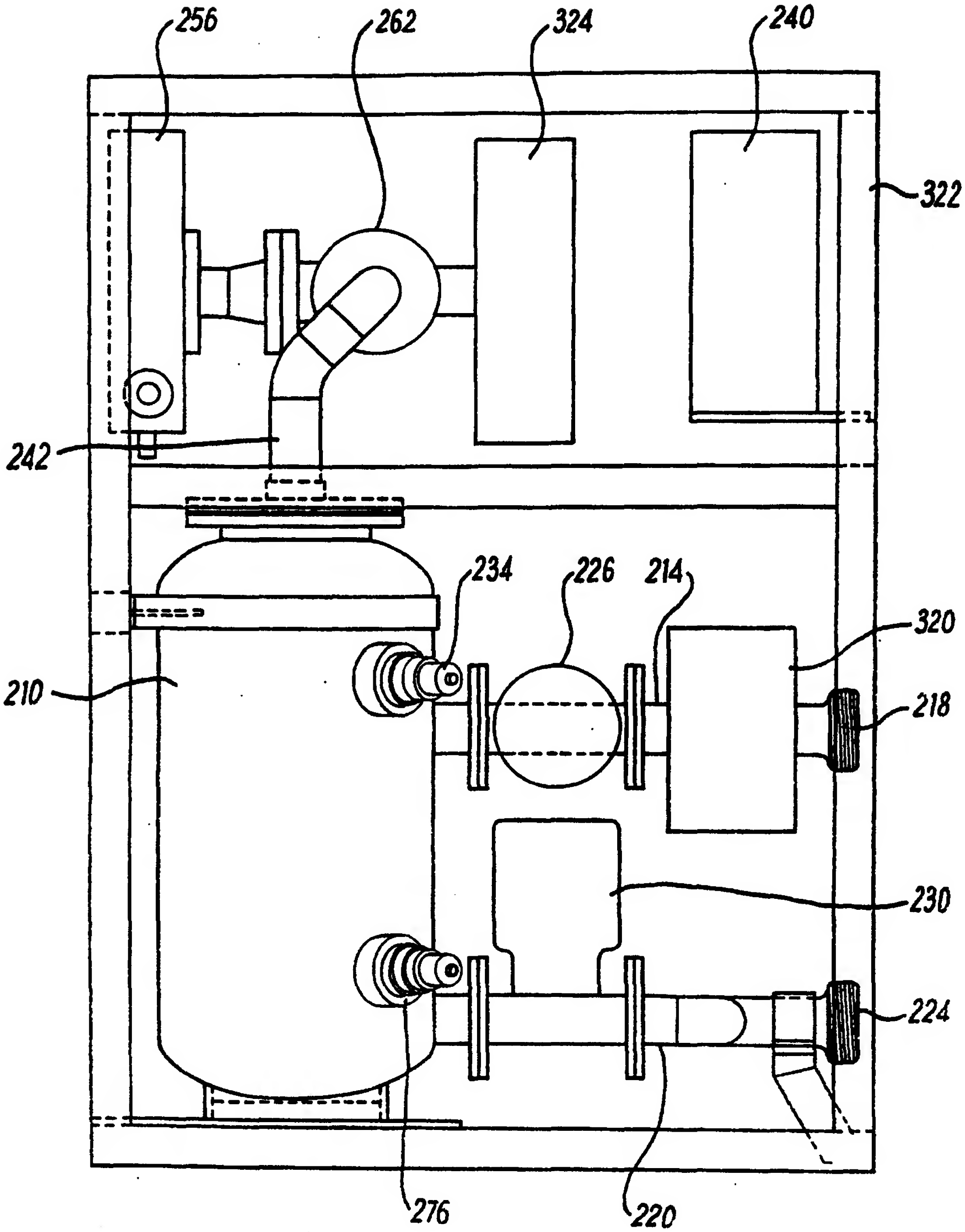

FIG. 23

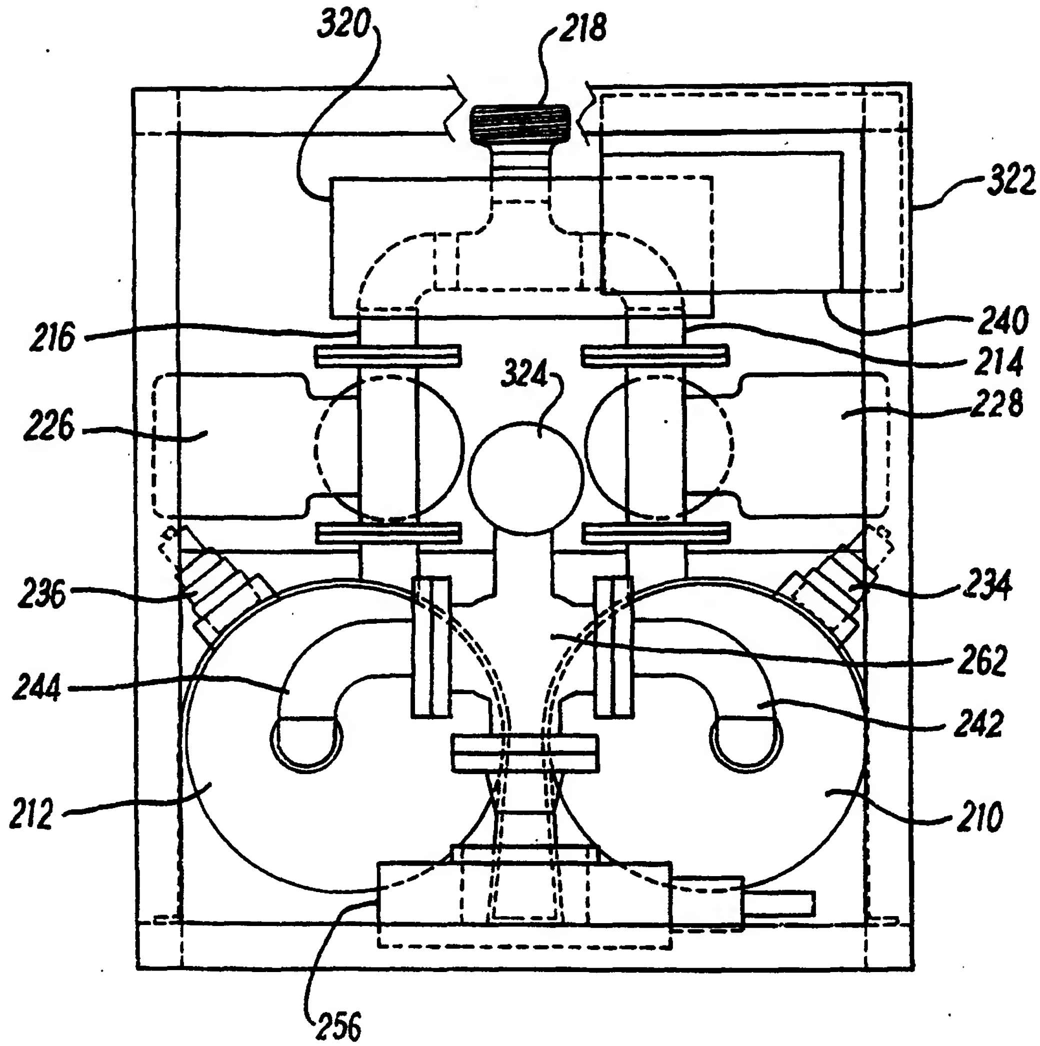
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FIG. 24